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LEADER IN DEPENDABILITY SINCE 1910

INSTRUCTION MANUAL
for
FREQUENCY DIFFERENCE METER
MODEL FDM 2100

MANUAL NO. 2490-621

THE HICKOK ELECTRICAL INSTRUMENT CO.
10514 DUPONT AVENUE • CLEVELAND, OHIO 44108

PHONE—(216) 541-8060

TWX—810-421-8286

PRINTED IN U.S.A.

I-20

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INSTRUCTION MANUAL
for
FREQUENCY DIFFERENCE METER
MODEL FDM 2100

FEDERAL ITEM NAME: METER, FREQUENCY DIFFERENTIAL
FEDERAL STOCK NUMBER: - - - - - 4931-369 8894
CONTRACT NUMBER: - - - - - DAAH01-70-0655
MANUFACTURER'S MODEL NUMBER: - - - - FDM 2100
MANUFACTURER'S PART NUMBER: - - - - - 902-482
APPLICABLE SERIAL NUMBERS: - - 155 THROUGH 165

NOTE

MAINTENANCE FORMS, RECORDS & REPORTS WHICH ARE TO
BE USED BY ALL MAINTENANCE PERSONNEL AT ALL MAINT-
ENANCE LEVELS ARE LISTED & PRESCRIBED BY TM 38-750.

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LIST OF EFFECTIVE PAGES

Total number of pages in this manual is 74 consisting of the following:

Page No.	# Change No.
Title	0
A	0
i	0
ii	0
1-1 - 1-3	0
1-4 Blank	0
2-1	0
3-0 - 3-6	0
4-1 - 4-5	0
4-6 Blank	0
5-1 - 5-3	0
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7-2 Blank	0
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7-4 Blank	0
7-5 - 7-9	0
7-10 Blank	0
7-11	0
7-12 Blank	0
7-13 - 7-30	0

Zero in this column indicates an original page.

TABLE OF CONTENTS

Section	Page	Section	Page
I GENERAL DESCRIPTION	1-1	4-3. Reference Input Circuitry . .	4-1
1-1. Introduction	1-1	4-6. Test Input/Error Multipli- cation Circuitry	4-1
1-4. Instrument Identification . . .	1-1	4-10. Metering and Display Circuitry	4-1
1-6. Specifications	1-3	4-13. Power Supplies	4-3
1-7. General Theory of Operation .	1-3		
II PREPARATION FOR USE	2-1	V MAINTENANCE, TROUBLE- SHOOTING AND CALIBRATION .	5-1
III OPERATING INSTRUCTIONS . . .	3-1	5-1. Introduction	5-1
3-1. Preliminary Information . . .	3-1	5-3. Preventive Maintenance . .	5-1
3-3. Methods of Readout	3-2	5-5. Corrective Maintenance . .	5-1
3-6. Operation	3-3	5-8. Calibration	5-2
3-11. Meter Readout	3-3	VI PARTS LIST	6-1
3-12. Internal Oscilloscope Readout .	3-3	6-1. Introduction	6-1
3-13. External Counter Readout . .	3-3	6-6. Maintenance Parts List . . .	6-1
3-14. External Recorder Readout .	3-6	6-8. List of Manufacturers . . .	6-1
3-15. External Oscilloscope Readout .	3-6	6-10. Notes	6-1
IV THEORY OF OPERATION	4-1	VII ILLUSTRATIONS	7-1
4-1. Introduction	4-1		

LIST OF ILLUSTRATIONS

Number	Title	Page	Number	Title	Page
1-1. Frequency Difference Meter FDM2100		1-1	7-4. Schematic Diagram, Error Multi- pliers (Assemblies A3, A4, A6, A7)		7-7
1-2. Simplified Block Diagram		1-2	7-5. Schematic Diagram, Crystal Filter (Assembly A5)		7-8
2-1. FDM2100 with Rack Mounting Slides .		2-1	7-6. Schematic Diagram, Buffer Amplifier (Assembly A8)		7-9
3-1. Front Panel Controls and Connectors .		3-0	7-7. Schematic Diagram, Comparator Countdown (Assembly A9) . . .		7-11
3-2. Rear Panel Controls and Connectors .		3-0	7-8. Schematic Diagram, Integrator- Differentiator (Assembly A10) .		7-13
3-3. Fractional Frequency Difference vs Display Movement in μ sec/sec or Spot Rotation in rotations/sec . . .		3-4	7-9. Schematic Diagram, Scope Driver (Assembly A11)		7-14
3-4. Fractional Frequency Difference vs Display Movement in sec/ μ sec or Spot Rotation in sec/rotation . . .		3-5	7-10. Schematic Diagram, Power Supply Regulator (Assembly A13) . . .		7-15
4-1. Overall Block Diagram		4-2	7-11. Schematic Diagram, Power Supply Rectifier (Assembly A14) . . .		7-16
4-2. Block Diagram of Reference Input Circuitry		4-3	7-12. Main Chassis, Top View, Parts Location		7-17
4-3. Block Diagram of Test Input Error Multiplication Circuitry		4-4	7-13. Main Chassis, Bottom View, Parts Location		7-18
4-4. Block Diagram of Metering and Display Circuitry		4-5	7-14. Main Chassis, Rear View, Parts Location		7-19
7-1. Schematic Diagram, Main Chassis Assembly		7-3	7-15. 5 MHz/1 MHz Divider, Printed Circuit Board, Parts Location (Assembly A1)		7-20
7-2. Schematic Diagram, 5 MHz/1 MHz Divider (Assembly A1)		7-5	7-16. Input/9 MHz Amplifier, Printed Circuit Board, Parts Location Assembly A2)		7-21
7-3. Schematic Diagram, Input/9 MHz/ Amplifier (Assembly A2)		7-6			

LIST OF ILLUSTRATIONS (Cont)

Number	Title	Page	Number	Title	Page
7-17.	First Error Multiplier, Printed Circuit Board, Parts Location (Assembly A3)	7-22	7-22.	Integrator-Differentiator, Printed Circuit Board, Parts Location (Assembly A10)	7-27
7-18.	Second, Third and Fourth Multipliers, Printed Circuit Board, Parts Location (Assemblies A4, A6 and A7)	7-23	7-23.	Scope Driver, Printed Circuit Board, Parts Location (Assembly A11)	7-28
7-19.	Crystal Filter, Printed Circuit Board, Parts Location (Assembly A5)	7-24	7-24.	Power Supply Regulator, Printed Circuit Board, Parts Location (Assembly A13)	7-29
7-20.	Buffer Amplifier, Printed Circuit Board, Parts Location (Assembly A8)	7-25	7-25.	Power Supply Rectifier, Printed Circuit Board, Parts Location (Assembly A14)	7-30
7-21.	Comparator-Countdown, Printed Circuit Board, Parts Location (Assembly A9)	7-26	7-26.	Power Supply Transistor and Heat Sink Bracket, Parts Location (Assembly A15)	7-30

LIST OF TABLES

Number	Title	Page
3-1	Controls and Connectors	3-1
5-1	Maintenance Check List	5-1
6-1	Maintenance Parts List	6-2
6-2	List of Manufacturers	6-19

SECTION I

GENERAL DESCRIPTION

1-1. INTRODUCTION.

1-2. The Hickok FDM2100 Frequency Difference Meter, shown in figure 1-1, is a highly reliable, all-silicon laboratory instrument capable of rapidly measuring small differences in frequency between two stable frequency sources. The internal capability for error multiplication by factors up to 10^4 makes this instrument far superior to classical methods utilizing Lissajous patterns or long gate time electronic counters.

1-3. The Hickok FDM2100 can also be used to set frequency offsets between two stable oscillators and to determine the relative drift rate between two sources. The difference between the two frequency sources under comparison may be read directly on

the front panel meter or may be read from the front panel oscilloscope using a stop watch. In addition, a pen recorder may be attached to the rear panel output jacks to monitor the difference frequency and an external counter may be used in conjunction with the 1 MHz and 1 MHz + 10NΔf output signals to display the test frequency.

1-4. INSTRUMENT IDENTIFICATION.

1-5. Each Hickok instrument is identified by a six-digit style number (manufacturer's part number) of the general form XXX-XXX and by a serial number. These numbers appear on the identification plate on the rear panel. It is important to reference both these numbers when communicating with Hickok about the Model FDM2100.

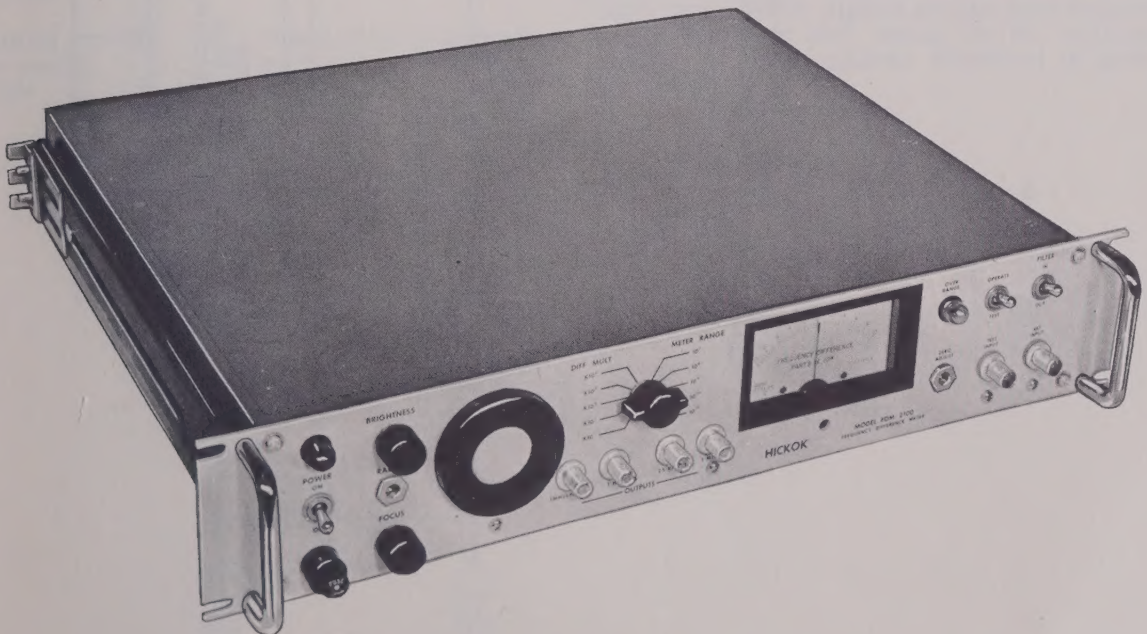


Figure 1-1. Frequency Difference Meter FDM 2100

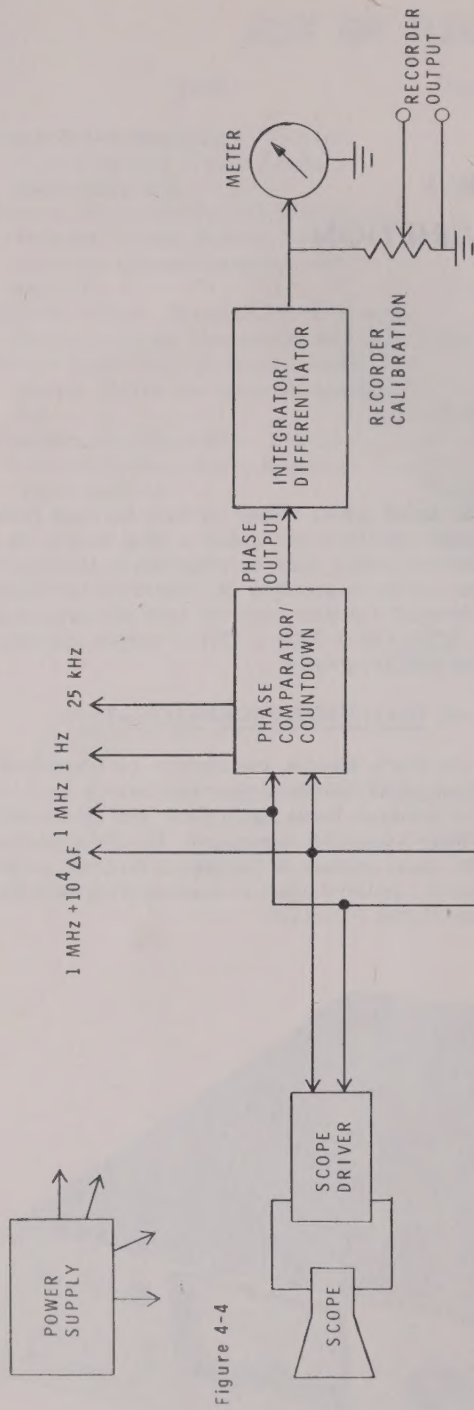


Figure 4-4

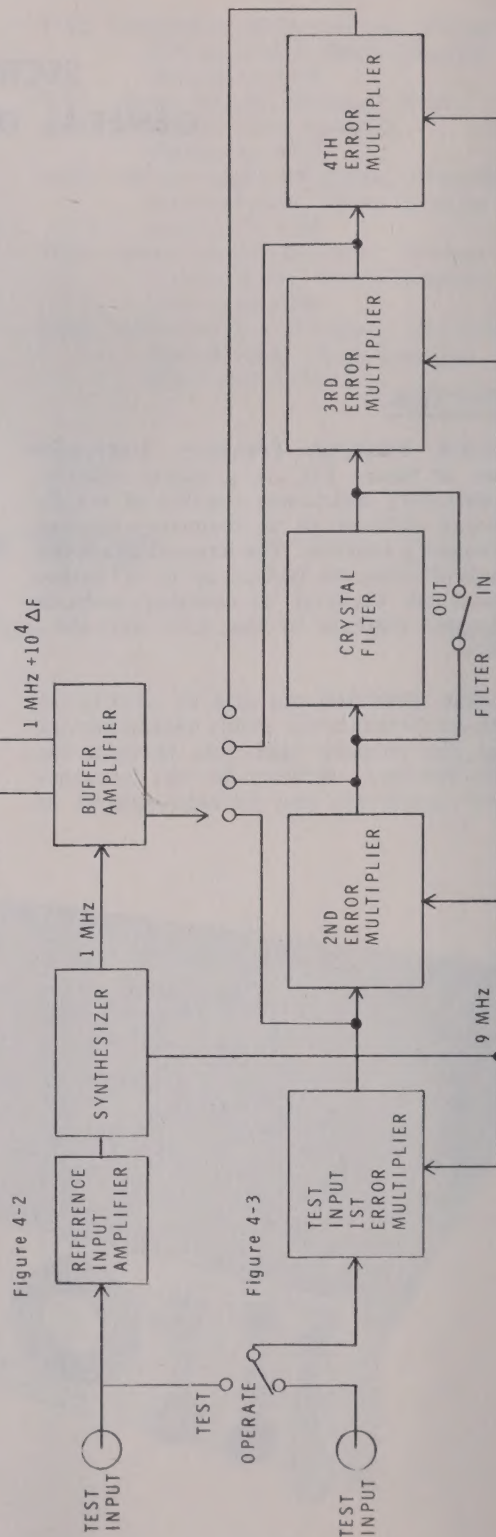


Figure 4-3

Figure 1-2. Simplified Block Diagram

1-6. SPECIFICATIONS.

Inputs

Input frequencies . . . 100 kHz, 200 kHz, 250 kHz,
500 kHz, 1 MHz, 2 MHz,
2.5 MHz, 5 MHz, $\pm 0.5\%$

Input level 0.5 - 10V RMS

Input impedance Nominally 1000 ohms

Input isolation Both inputs are isolated
from circuit ground

Error multiplication . . . $X10^1$, $X10^2$, $X10^3$, $X10^4$

Panel meter Display ΔF in "parts in 10^N ",
 $10^N = 10^7$ through 10^{11} as
selected by range switch

Oscilloscope Display $\cos M\Delta F$ vs $\sin M\Delta F$,
where $M = 10^1$ through 10^4

Outputs

1 MHz reference 100mV minimum

1 MHz + $10 \Delta F$ 100mV minimum

1 Hz reference 2V P-P minimum

25kHz reference 2V P-P minimum

ΔF 0-10 parts in 10^N , 10 parts =
500 μA into $\leq 2K\Omega$

"N" 8421 BCD switch closure

Power 115/230 $\pm 10\%$ VAC RMS, 50 Hz-
requirements 400 Hz (115-230 operation selec-
able with rear panel switch),
input power $\leq 25W$

Mechanical

Mounting Standard 19" relay rack

Dimensions 3.5" high, 19" wide, 18" deep

Weight 20 lbs

Operational environment $+4^\circ C$ to $+40^\circ C$
0 to 90% relative humidity
0 to 10,000 feet altitude

Storage environment $-55^\circ C$ to $+60^\circ C$
0 to 40,000 feet altitude

1-7. GENERAL THEORY OF OPERATION.

1-8. The following paragraphs are intended to provide a simplified overview of the theory of operation of the Hickok FDM2100. While reading the following paragraphs, reference should be made to figure 1-2, Simplified Block Diagram.

1-9. Any of the allowable reference input frequencies (any sub-multiple of 5 MHz) may be used as inputs to the synthesizer. The synthesizer generates a 1 MHz reference signal which is available at a front panel output jack, and a 9 MHz reference signal which is used in the error multipliers. The synthesized 1 MHz and 9 MHz signals exhibit the same accuracy and stability as does the reference input signal. For example, if the reference input is actually 500,000.005 Hz the 1 MHz output will be 1,000,000.01 Hz. If the stability of the 500 kHz reference input is 10^{-3} ppm per day, the stability of the 1 MHz output will also be 10^{-3} ppm per day. The test input is directed to the four error multipliers when the TEST OPERATE switch is in the OPERATE position. The range switch is used to select the appropriate error multiplier output. The 1 MHz reference signal and the $1 \text{ MHz} + 10^1 \Delta F$ signal generated by the error multipliers from the TEST INPUT are fed to the phase comparator and then to an integrator/differentiator/buffer, the output of which is used to drive both the meter and the recorder output jacks. A crystal filter has been provided between the second and third error multipliers to facilitate reduction of phase noise. The 1 MHz and $1 \text{ MHz} + 10^N \Delta F$ signals are also used to generate $\cos M\Delta F$ and $\sin M\Delta F$ signals for the oscilloscope display. A more complete discussion is given in Section IV.

SECTION II

PREPARATION FOR USE

2-1. The Hickok FDM2100 requires no special installation procedure; all that is required is a power source in accordance with requirements stated in Section I. Before placing the Hickok FDM2100 in operation, the instrument should be inspected for obvious physical damage, especially in areas where the shipping container shows signs of mistreatment. It is also suggested that the remainder of this instruction book, especially Section III, be read before this instrument is used.

2-2. The Hickok FDM2100 is reasonably well protected from susceptibility to external electric and magnetic fields but, because of its extreme sensitivity, it should not be operated in the presence of

strong external fields. Excessive influence of low frequency external fields will affect the readout of fractional frequency difference much in the same way as would excessive phase noise on the input signal lines. Likewise, excessive vibration in the operational environment will, through mechanical modulation, affect the readout in a similar manner.

2-3. When rack mounting the Hickok FDM2100, first ascertain that adequate room is available to permit free circulation of air.

2-4. If the Hickok FDM2100 has been supplied with chassis slides, refer to figure 2-1 for mounting information.

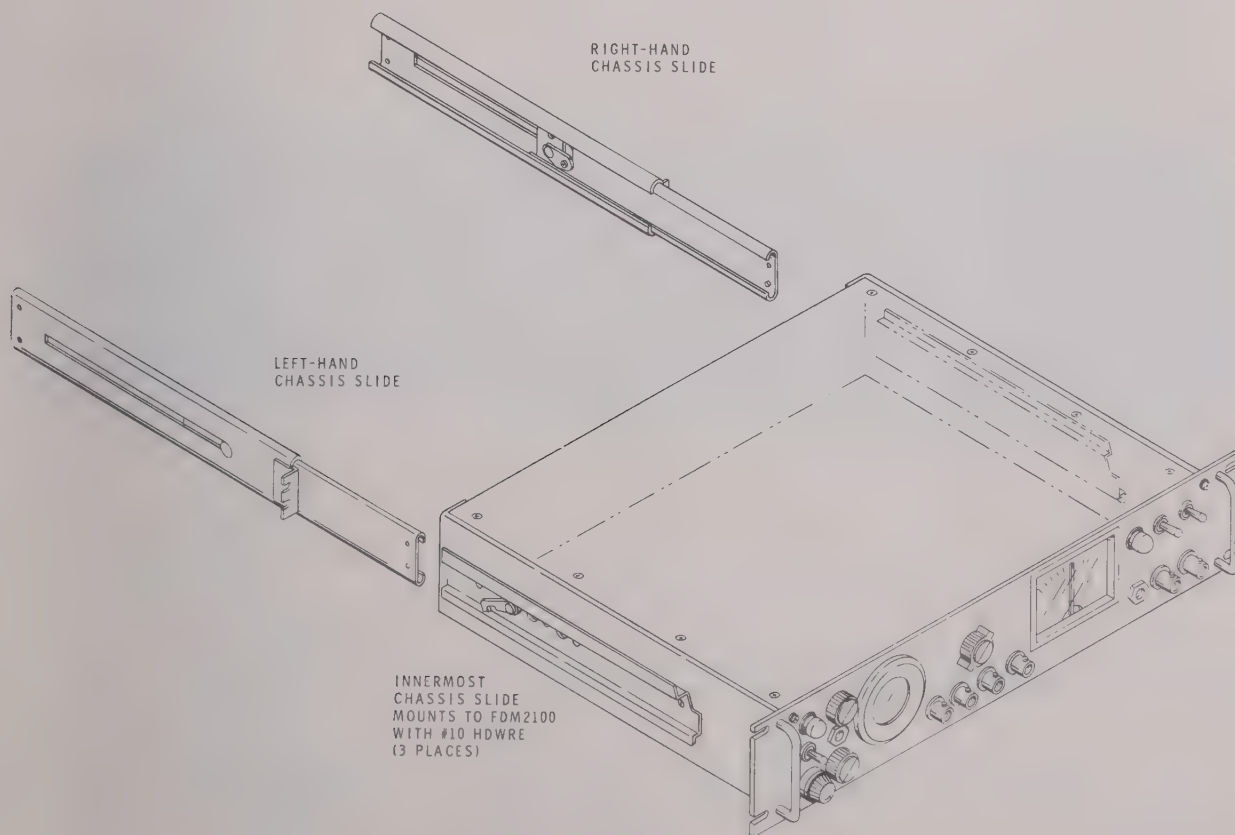


Figure 2-1. FDM2100 with Rack Mounting Slides

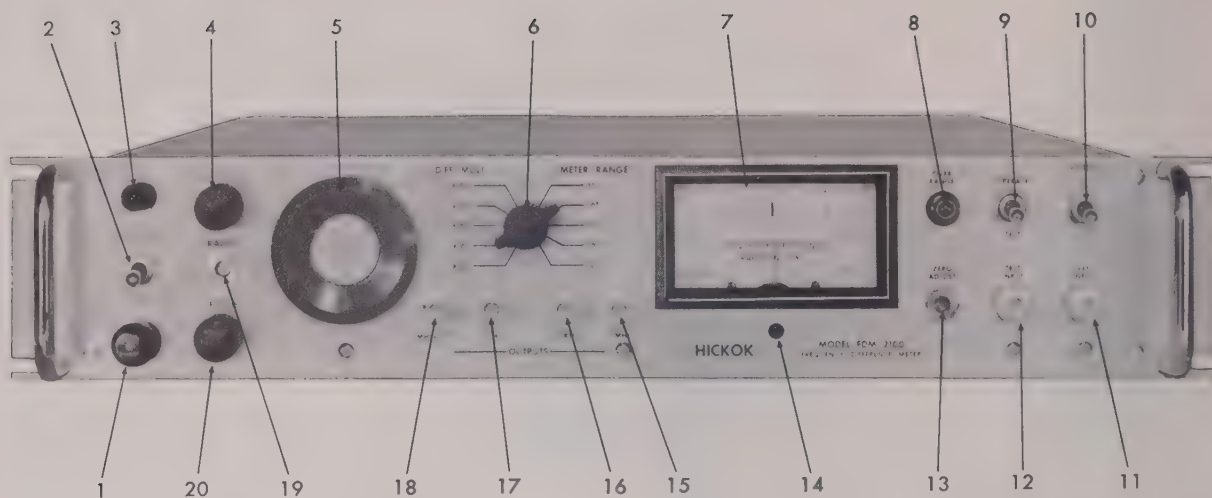


Figure 3-1. Front Panel Controls and Connectors

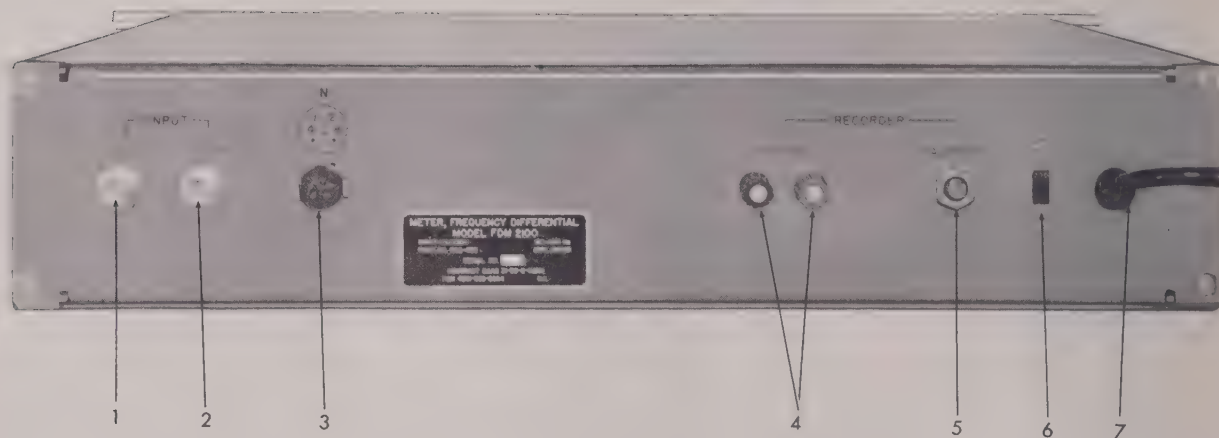


Figure 3-2. Rear Panel Controls and Connectors

SECTION III

OPERATING INSTRUCTIONS

3-1. PRELIMINARY INFORMATION.

3-2. Figures 3-1 and 3-2 identify the front and rear panel controls and the operator should familiarize himself with the purpose and function of each as detailed in table 3-1. Note that the front panel input jacks have been duplicated on the rear panel for convenience in rack-mounted applications. Ascertain

that the 115-230 switch is correctly set and plug the instrument into an appropriate input power source. Turn on the power switch and note that the pilot light immediately turns on. The meter readout as well as all inputs and outputs are functional as soon as power has been applied to the instrument. The oscilloscope, however, will require a few minutes' warmup.

Table 3-1. Controls and Connectors

Index No.	Figure	Name	Function
1	3-1	FUSE	Protects instrument and power source against over-currents. Use 1 AMP, fast blow for 115 VAC operation. Use 1/2 AMP, fast blow for 230 VAC operation.
2	3-1	POWER switch	Disconnects FDM2100 from both sides of power line in OFF position.
3	3-1	POWER lamp	Glowes when POWER switch (index 2, above) is in ON position and proper input voltage has been applied to the line cord.
4	3-1	BRIGHTNESS	This control permits the operator to vary the intensity of the oscilloscope display. This control should be set to the position which yields the minimum acceptable display intensity consistent with ambient light levels, as prolonged operation at the highest intensity will cause the display tube phosphor to "burn."
5	3-1	Oscilloscope	This 1" diameter CRT provides a display of $\cos M\Delta F$ vs $\sin M\Delta F$ where M is the setting of the DIFFERENCE MULTIPLIER and ΔF is the frequency difference between the REFERENCE INPUT and the TEST INPUT (with both normalized to 1 MHz).
6	3-1	Range switch	This switch selects both the multiplier for the oscilloscope display and the meter range.
7	3-1	Meter	The meter provides a readout of ΔF in "parts in 10^N " from -10 parts to +10 parts for all meter ranges.
8	3-1	OVER RANGE light	This lamp indicates either when excessive phase noise is present on the input signals, when the difference frequency is beyond the range of the meter or when the FDM2100 is subjected to excessive vibration.
9	3-1	TEST/ OPERATE switch	This switch provides facility for connecting both the REF and TEST INPUTS to the reference input signal. This is desirable when setting the electrical meter zero or when checking the inputs for phase noise.

Table 3-1. Controls and Connectors (Cont.)

Index No.	Figure	Name	Function
10	3-1	FILTER switch	This switch provides means for inserting a crystal filter between the second and third error multipliers. With the filter in, input frequencies must be within 0.5 ppm of nominal.
11 1	3-1 3-2	REF INPUT	Either of these jacks may be used to connect the reference signal to the FDM2100. These jacks are electrically isolated from the chassis (circuit ground) and the FDM2100 may be operated with these inputs as much as 500 VDC from ground.
12 2	3-1 3-2	TEST INPUT	Either of these jacks may be used to connect the unknown (or TEST) inputs to the FDM2100. Like the REF INPUT jacks, these jacks are isolated from circuit ground.
13	3-1	ZERO ADJUST	This control provides for electrical meter zero adjustment.
14	3-1	Zero adjust	This recessed screw provides for mechanical meter zero adjustment.
15 16 17 18	3-1 3-1 3-1 3-1	OUTPUTS	These jacks provide front panel access to 1 MHz, 25 kHz and 1 Hz derived from the REF INPUT and to 1 MHz + 10^N Hz derived from the TEST INPUT
19	3-1	RADIUS control	This control provides for changing the radius of the oscilloscope display.
20	3-1	FOCUS control	This control provides for adjustment of oscilloscope trace definition.
3	3-2	N output jack	This jack provides a switch closure output in 8421 BCD of the meter range exponent.
4	3-2	RECORDER OUTPUT	This output will drive a 500 μ A recorder with input resistance up to 2,000 Ω . The output current is proportional to meter deflection.
5	3-2	RECORDER CALIBRATE control	This potentiometer provides for setting full scale recorder output at any value from 0 μ A to 500 μ A.
6	3-2	Line voltage selector	This control provides for selecting the proper internal power supply input configuration for either 115 or 230 VAC operation.
7	3-2	Line cord	The line cord is equipped with a three-pronged grounding type plug.

3-3. METHODS OF READOUT.

3-4. The methods of readout self-contained in the FDM2100 consist of the front panel meter which displays the fractional frequency difference between two stable frequency sources in terms of "parts in 10^N " where N may be selected to be any integer from seven through eleven. The self-contained oscilloscope display continuously plots a real-time graph of $\cos M\Delta F$ vs $\sin M\Delta F$ where M is the difference multiplication factor of 10^1 through 10^4 . As the spot on the oscilloscope display will make one revolution per second for every cycle per second difference of the error-multiplied test signal as referenced to the

reference signal, a stop watch may be employed to time these rotations and permit readout of the difference frequency.

3-5. There are three external methods which may be employed to read the frequency difference. An external electronic counter utilizing either its own time base or utilizing the 1 MHz reference output as its time base may be used to display the 1 MHz + 10^N Hz error multiplier test signal output. It is far more desirable to use the 1 MHz reference output as an external time base for the electronic counter because use of the electronic time base for this method of readout will result in an offset in the

readings proportional to the difference between the reference input frequency and the counter time base frequency. For large error multiplications when the difference between the counter time base and reference input frequencies is small, this offset error factor may be ignored. The second external method of readout consists of attaching a chart recorder to the external recorder output jacks on the rear panel. This external recorder's sensitivity must be equal to or better than 500 microamperes full scale with an input impedance of not more than 2000 ohms if it is a galvanic recorder, or it must have a full scale sensitivity of 1 VDC or better and an input impedance of not less than 200k ohms if it is a potentiometric recorder. This method of readout is extremely useful in determining relative drift rates between two stable frequency sources or when a permanent record is desired of a given frequency offset over a period of time. The third method of external readout consists of using an external oscilloscope in one of two ways. Firstly, the external oscilloscope may be used to display the $1 \text{ MHz} + 10^N \Delta F$ output when synchronized to any of the reference outputs and the movement of the display may be timed to yield a frequency difference reading or the 1 MHz output and the $1 \text{ MHz} + 10^N$ output may be applied to the x and y inputs of the oscilloscope to obtain the familiar Lissajous pattern.

3-6. OPERATION.

3-7. The mechanical meter adjustment should be made before using the FDM2100 if, with no power applied to the instrument, the meter pointer does not coincide with the center-scale zero mark on the meter dial. If adjustment is required, the mechanical meter adjustment screw (14, figure 3-1) should be adjusted to produce the desired coincidence with no power applied to the instrument.

3-8. The following paragraphs detail specific instructions for the various methods of readout.

3-9. Proper setup of the inputs is essential for operation with any method of readout.

3-10. Because of the extreme sensitivity of the FDM2100, caution must be exercised in hookup of signal sources to the REF and TEST inputs to avoid crosstalk between the two separate channels. Because of the isolated inputs, the REF and TEST signal sources may be operated at DC potentials differing by up to 500 volts and some degree of common-mode rejection results at low frequencies. Nevertheless, care should still be exercised to insure that all input leads are properly shielded. Particular care must be taken to prevent crosstalk between the TEST input, the REF input (and 1 MHz, 25 kHz and 1 Hz outputs) and the $1 \text{ MHz} + 10^N \Delta F$ output, as crosstalk between these signals will result in modulation of the readout at the difference frequency.

3-11. METER READOUT.

a. Properly connect the inputs to the FDM2100, observing the above precautions.

b. Set the TEST-OPERATE switch to the TEST position and adjust the electrical METER ZERO control (13, figure 3-1) for zero meter indication (center-scale).

c. Return the TEST-OPERATE switch to the OPERATE position.

d. Set the DIFF MULT/METER RANGE switch to the most clockwise position yielding an on-scale reading with the OVER RANGE lamp extinguished.

e. Read the frequency offset of the TEST input (with respect to the REF input) directly as the product of the range switch setting and the meter reading.

3-12. INTERNAL OSCILLOSCOPE READOUT.

a. Properly connect the inputs to the FDM2100, observing the precautions described earlier in this section.

b. Adjust the BRIGHTNESS and FOCUS controls for the most well-defined, smallest and dimmest spot readily observable. If, through prolonged operation at too great a brightness level, the CRT display is interrupted by burned areas in the CRT phosphor, shift the trace by use of the RADIUS control.

c. Frequency offset may be read by timing revolutions of the oscilloscope trace and by application of the graphs in figures 3-3 and 3-4. For rapid calculations without reference to these graphs, recall that the internal oscilloscope display is a real-time graph of $\sin M \Delta F$ vs $\cos M \Delta F$, where M represents the setting of the DIFF MULT switch.

3-13. EXTERNAL COUNTER READOUT.

a. With internal time base:

1. Connect the $1 \text{ MHz} + 10^N \Delta F$ output to the frequency input of an electronic counter with at least 100mV sensitivity.

2. Set the TEST-OPERATE switch to the TEST position and note the reference frequency, using the shortest time base commensurate with the accuracy requirements of the desired measurement. Recall that the accuracy of any digital counter with a time base signal asynchronous with the input signal is necessarily $\pm 1 \text{ digit} \pm \text{gate time uncertainty}$.

3. Return the TEST-OPERATE switch to the OPERATE position and read the $1 \text{ MHz} + 10^N \Delta F$ signal.

4. For example, if the result of step (2) is 1,000,000.5 Hz and the result of step (3) is 1,000,010.5 Hz and if the DIFF MULT switch is set to 10^2 , then the TEST input frequency is one part in 10^7 greater than the REF input frequency.

b. With external time base:

1. The same procedure as listed above applies with the exception that, by using the 1MHz REF output as an external time base to the counter, step (2) may

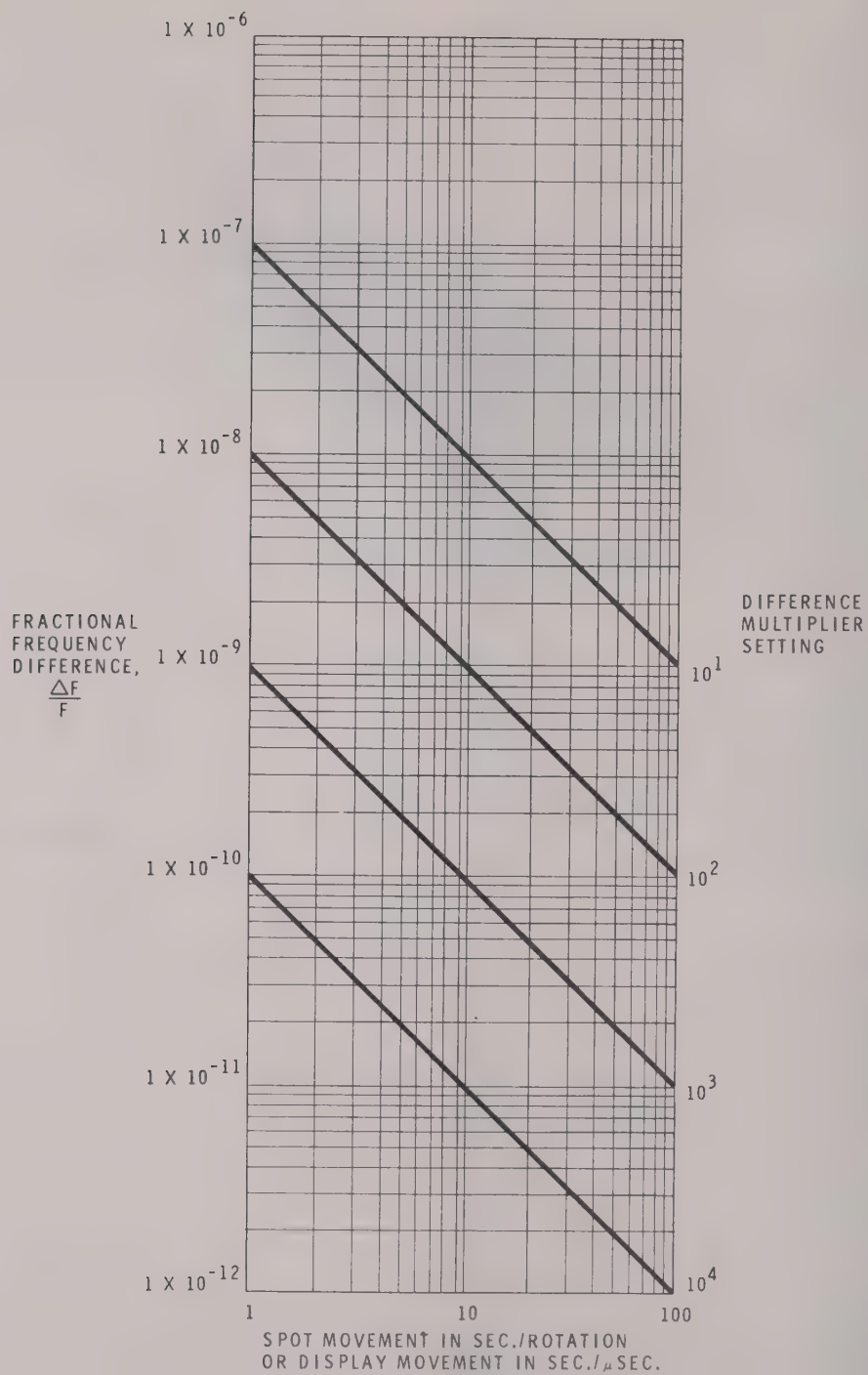


Figure 3-3. Fractional Frequency Difference vs Display Movement in μ sec/sec or Spot Rotation in rotations/sec

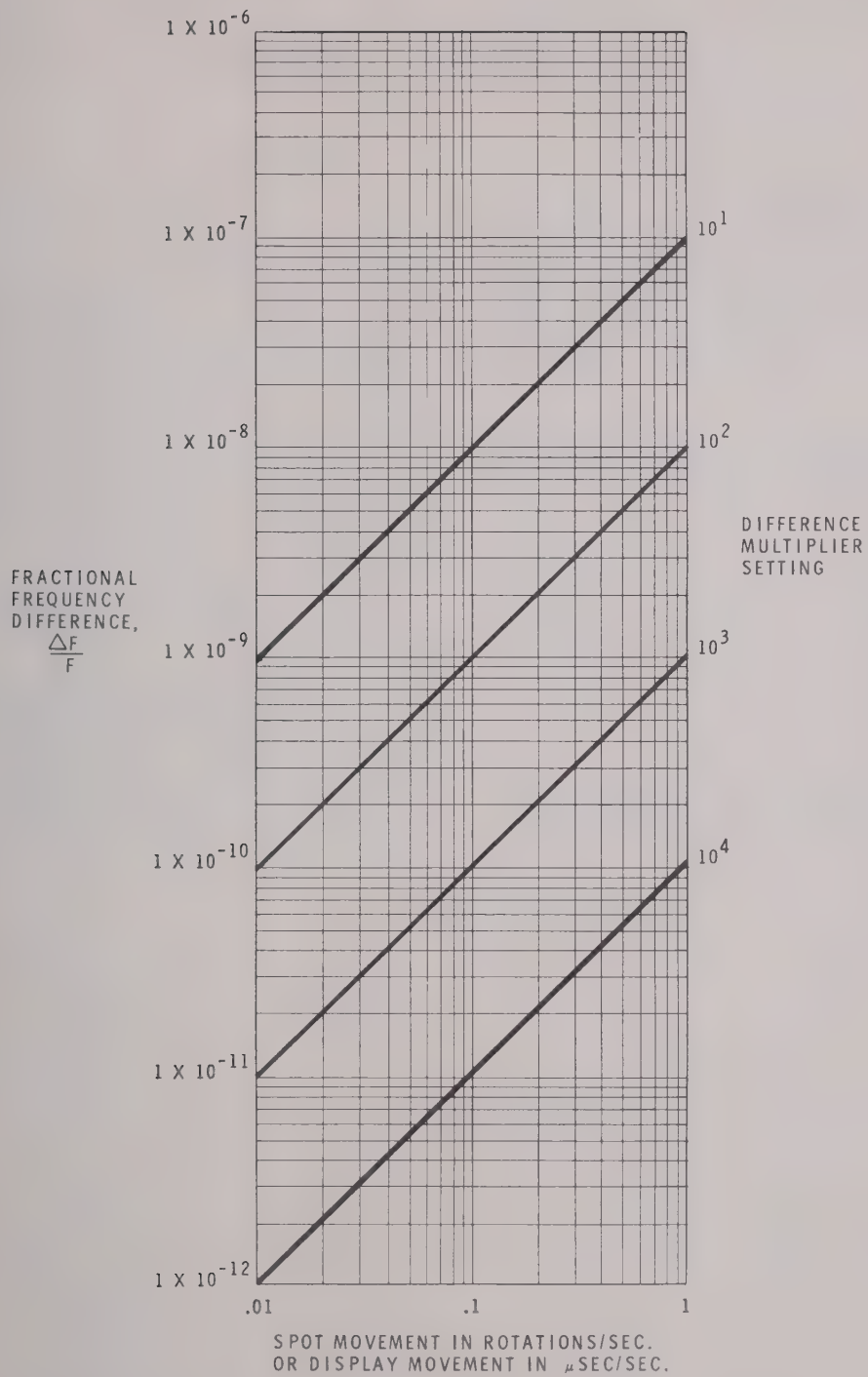


Figure 3-4. Fractional Frequency Difference vs Display Movement in sec/ μsec or Spot Rotation in sec/rotation

be eliminated. Merely measure the frequency of the 1 MHz + 10^NΔF output (with the TEST-OPERATE switch in the OPERATE position) and read frequency offset as the difference between the reading and 1MHz, all divided by the DIFF MULT setting. Example:

$$\Delta F = \left(\frac{\text{COUNTER READING} - 1 \text{ MHz}}{\text{DIFF MULT setting}} \right)$$

3-14. EXTERNAL RECORDER READOUT.

a. The Thevenin equivalent of the recorder output circuitry is a 0 to ±2 VDC source in series with 2000Ω. A RECORDER CALIBRATE control has been provided on the rear panel to afford easy adjustment of the recorder output signal to whatever value is appropriate for the recorder being used. Connect the recorder being used to the output jacks on the rear panel.

b. With signals applied to both the TEST and REF inputs, adjust the RECORDER CALIBRATE control to provide a reading on the recorder corresponding to the meter reading.

c. The magnitude of the recorder reading is then the frequency offset, and the difference between two offsets noted at the end points of a given time interval is the drift of the TEST input signal with respect to the REF input over that time interval. Dividing the drift by the time interval yields the drift rate.

NOTE

To make very accurate drift rate measurements when using sources whose peak-to-peak frequency deviations are significantly large

as compared to anticipated drift rate, repeat the drift rate measurement several times and average the results.

3-15. EXTERNAL OSCILLOSCOPE READOUT.

a. Using oscilloscope with external trigger capability:

1. Connect the 1 MHz + 10^NΔF output signal to the vertical input.

2. Connect the 1 MHz reference output signal to the external trigger input.

3. Determine the display drift rate in μsec/sec at the maximum usable DIFF MULT setting on the FDM2100. The frequency offset is the product of the display drift rate (in μsec/sec) times the DIFF MULT setting times 10⁶. Pattern movements to the right represent positive offsets and leftward moving displays represent negative offsets.

b. Using oscilloscope with X-Y capability:

1. Connect the 1 MHz + 10^NΔF output signal to the vertical input.

2. Connect the 1 MHz reference output signal to the horizontal input.

3. Time the rate of Lissajous pattern rotation and determine the frequency offset as being the product of 10⁶ times the DIFF MULT setting times the rotation speed of the display. Again, use the maximum DIFF MULT setting that permits timing of rotations. A clockwise rotation denotes a positive offset of the TEST input with respect to the REF input.

SECTION IV

THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. This section presents a detailed analysis of the theory of operation of the Hickok FDM2100. A simplified overview of the theory of operation was provided in paragraph 1-7 and the generalized block diagram (fig. 1-2) presented there has been reproduced here with dashed lines added to delineate the subsections more explicitly detailed in the block diagrams of figures 4-2, 4-3, and 4-4.

4-3. REFERENCE INPUT CIRCUITRY.

4-4. The general structure of the reference input circuitry is illustrated in figure 4-2. This circuitry normalizes the reference input to a frequency of 5 MHz, retaining the accuracy and stability of the reference input signal. The bandwidth of the circuitry is broad enough so that reference input signals may deviate as much as 0.5% from the nominal values allowed. The values allowed consist of any integral submultiple of 5 MHz at any level between 0.5 and 10 V RMS. A tighter limitation on reference input signal frequency must be imposed, however, when the crystal filter switch is set to the IN position: when the CRYSTAL FILTER switch is set to the IN position: when the crystal filter is in use, all input signals must be within five parts in 10^7 of their nominal value when the range switch is set to either the 10^{10} or 10^{11} position.

4-5. The reference input signal is coupled through an isolation transformer to a differential amplifier consisting of A2Q1 and A2Q2, the output of which is directed to a Schmitt trigger (A2Q3, A2Q4) where it is shaped into a square wave. The output of A2Q4 is twice differentiated and then clipped by A2C3, A2R14, A2C8, A2R15 and A2CR4 before being fed to the two 5 MHz tuned circuits (A2C9, A2C10, T1, A2C12, A2T3). The 5 MHz output of T2 serves as one input to the synthesizer circuitry contained on assembly A1. Assembly A2 itself contains the other synthesizer input, a free-running 4 MHz oscillator (A1Q7, A1Q8, A1Q9). Two mixers consisting of A1Q2, A1Q4 and A1Q5, A1Q6 are used to generate the sum and difference frequencies from the 5 MHz and 4 MHz signals. The 9 MHz signal is returned to assembly A2 where it is amplified and filtered by the circuitry associated with A2Q5 and A2Q6. This 9 MHz signal serves as one input to the error multiplication circuitry block diagrammed in figure 4-3. The 1 MHz output from the mixers is used as a synchronization input to the free-running 4 MHz oscillator and must be set closely because other stable harmonic relationships are possible: for example, 3.75/1.25; 3.33/1.66; 3.00 (6.00)/1.00; 2.50/2.50; etc.

4-6. TEST INPUT/ERROR MULTIPLICATION CIRCUITRY.

4-7. Figure 4-3 details the structure of the TEST input and error multiplication circuitry. The same constraints on bandwidth and input sensitivity as were given for the REFERENCE input apply to the TEST input signal as well.

4-8. The TEST input signal is coupled through an isolation transformer to a differential amplifier (A3Q1, A3Q2) before being shaped by a Schmitt trigger (A3Q3, A3Q4), differentiated and clipped and used to drive a 10 MHz tuned circuit. Thus, if the TEST input frequency is $f_T \cong 1$ MHz, the output of the 10 MHz tank is $10f_T$. Furthermore, if the REF input frequency is $f_R \cong 1$ MHz and $f_T = f_R + \Delta F$, then the output of the 10 MHz tank is $10f_R + 10\Delta F$.

4-9. Recalling that the REF input signal was used to generate a 9 MHz signal of the same accuracy and stability of the REF input signal, we can now achieve error multiplication by mixing the $10f_R + 10\Delta F$ with the $9f_R$ (again, assuming $f_T \cong f_R \cong 1$ MHz) and selecting the difference frequency which is $10f_R + 10\Delta F - 9f_R + 10\Delta F$, which is a signal differing from the REF input frequency by ten times the amount that the TEST input does. Successive stages provide additional error multiplication so that the last stage output is $f_R + 10^4\Delta F$. This argument may be extended to cover all combinations of REF and TEST input signals at frequencies of any submultiple of 5 MHz. For example, a REF input of 1 MHz may be compared with a TEST input of 2.5 MHz and the indicated result will be the same as if a comparison were being made between two 1 MHz signals exhibiting the same accuracy and stability as the actual 1 MHz and 2.5 MHz inputs. In summary, signal flow in this section is from A3 to A4 to A5 to A6 to A7, with each assembly except A5 multiplying the fractional frequency difference by a factor of ten. A5 is a crystal filter which serves to reduce phase noise and jitter and is placed strategically between the second and third error multipliers to best suit the needs of laboratory quality oscillators.

4-10. METERING AND DISPLAY CIRCUITRY.

4-11. Figure 4-4 details the circuitry used to generate the oscilloscope display, the meter and recorder outputs, and the auxiliary outputs from the 1 MHz and $1 \text{ MHz} + 10^N \Delta F$ signals generated by the circuitry depicted in figures 4-2 and 4-3, respectively. The two buffer amplifiers contained on assembly A8 serve to amplify and isolate the 1 MHz signal generated by assemblies A1 and A2, and the 1 MHz +

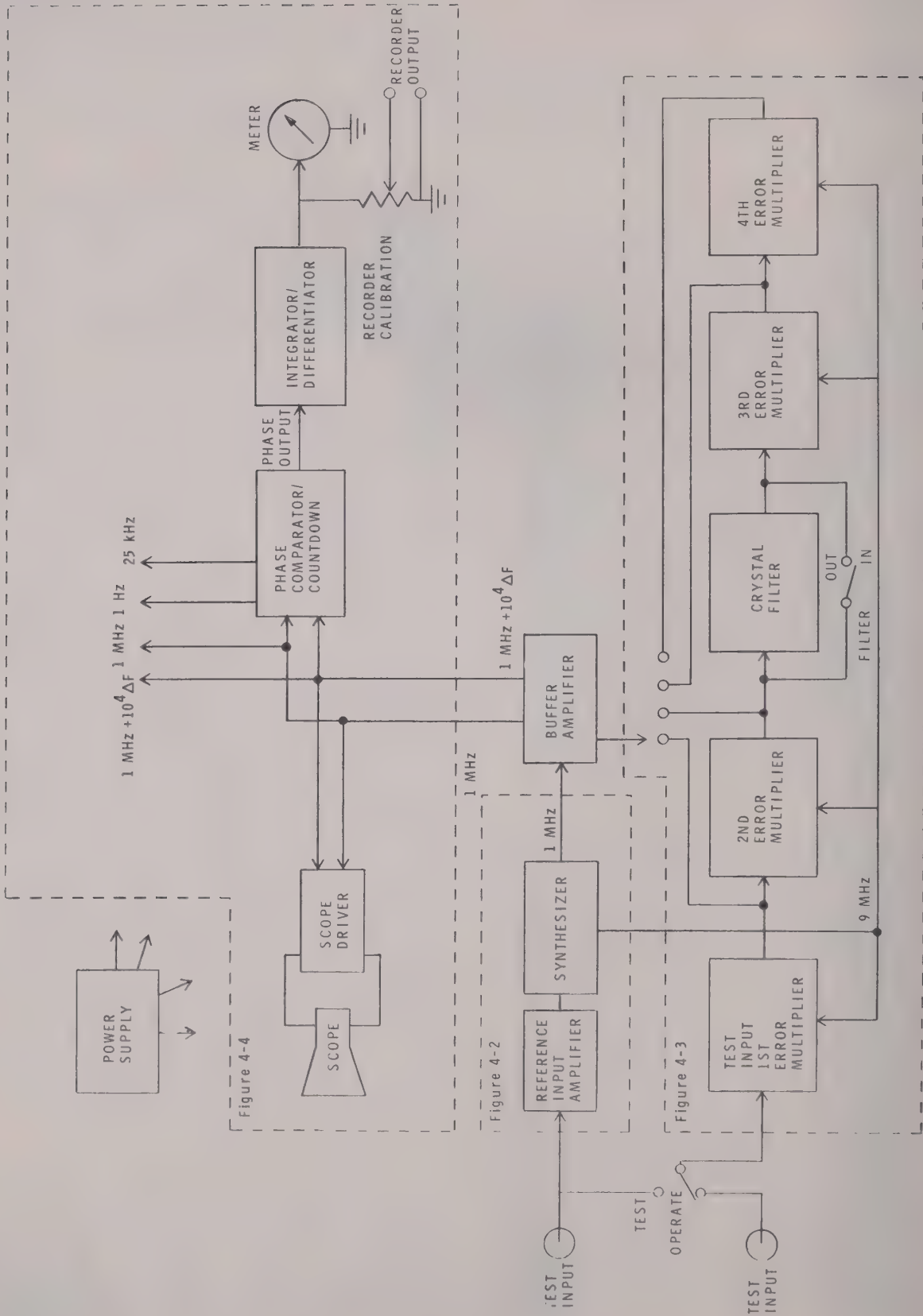


Figure 4-1. Overall Block Diagram

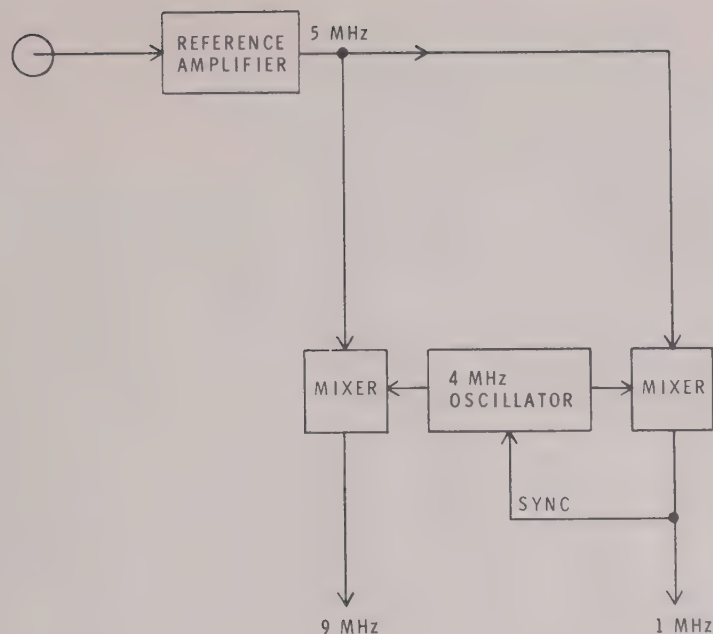


Figure 4-2. Block Diagram of Reference Input Circuitry

$10^N \Delta F$ signal generated by assemblies A3 through A7. The buffered 1 MHz signal is fed to assembly A9 where a series of integrated circuit decade counters and an integrated circuit J-K flip-flop are used to generate the 1 Hz and 25 kHz output signals. These two signals are again buffered before appearing at J7 and J8 as output signals. Assembly A9 contains three more integrated circuit J-K flip-flops, two of which are used to scale by two the incoming buffered 1 MHz and $1 \text{ MHz} + 10^N \Delta F$ signals and the third of which is used in an RS configuration as a phase detector. Transistors A9Q8, 9 perform a NOR gate coincidence detector, sampling the output of the divide-by-two scalers and providing reset and blanking information when proper operation of the phase detector is endangered through too proximate an occurrence of the set and reset information generated by the scalers. The blanking information is used to disable the final meter amplifier while the system is being reset. The output of the phase detector is a pulse width modulated wave form with pulse width proportional to the phase difference between the two incoming scale signals. Assembly R10 contains an RC integrator which transforms this pulse width modulation into a linear ramp the height of which is proportional to phase difference. The following stage is a differentiator whose output is a voltage level proportional to frequency difference since the first derivative of the linear ramp is the rate of change of phase difference: namely, frequency difference. Assembly A10 also contains a buffer amplifier, A10IC2, whose input is gated through A10Q3 by action of the blanking pulse generated by the monostable multivibrator (the circuitry associated with transistors A9Q10 through A9Q13) under command of the NOR gate coincidence detector (A9Q8, A9Q9).

4-12. The blanking pulse triggers a monostable switch (A8Q1, 2, 3) which is used to drive the OVER RANGE light with a fixed amount of energy at a frequency equal to that of the blanking pulse. The buffered signals from A8Q7, 8, 9 (1 MHz) and from A8Q4, 5, 6 ($1 \text{ MHz} + 10^N \Delta F$) are mixed by A11Q4, 5 and A11Q7, 8, respectively, after the 1 MHz signal has been phase split to generate the cosine MΔF and sine MΔF functions for the oscilloscope display.

4-13. POWER SUPPLIES.

4-14. Assemblies A13, A14 and A15 comprise the five power supplies required for proper operation of the FDM2100. Assembly A15 contains the four series pass transistors used in the +15, +9, +3.6 and -15 volt supplies. Assembly A14 contains the rectifiers and filter capacitors for these four supplies as well as the rectifier and filter capacitor required for the cathode ray tube, V1. Assembly A13 contains the electronic regulating circuitry associated with the four series pass transistors on assembly A15. The four regulated supplies are relatively standard, utilizing a Darlington series pass arrangement, a diode resistor current limiting circuit and a differential error amplifier. The +15V supply and the +3.6V supply utilize the same zener reference diode while the -15V and +9V supplies each contain their own reference diode. Assembly A12 is an extender board assembly and for ease in troubleshooting the regulated power supply output voltages appear at the top of the extender board as follows: +15V, Pin 3; +9V, Pin 9; +3.6V, Pin 7; power supply ground, Pin 11; -15V, Pin 15.

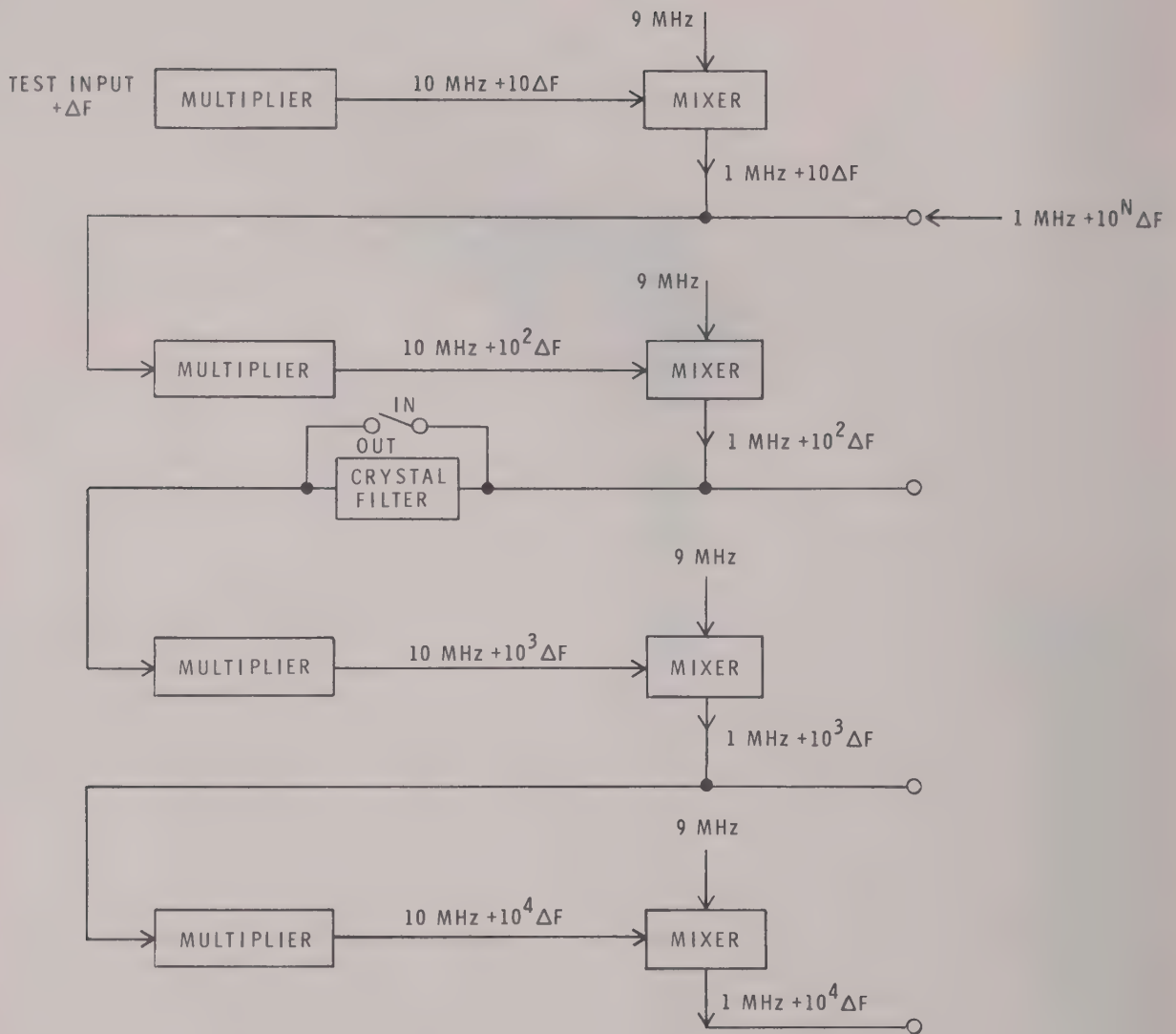


Figure 4-3. Block Diagram of Test Input Error Multiplication Circuitry

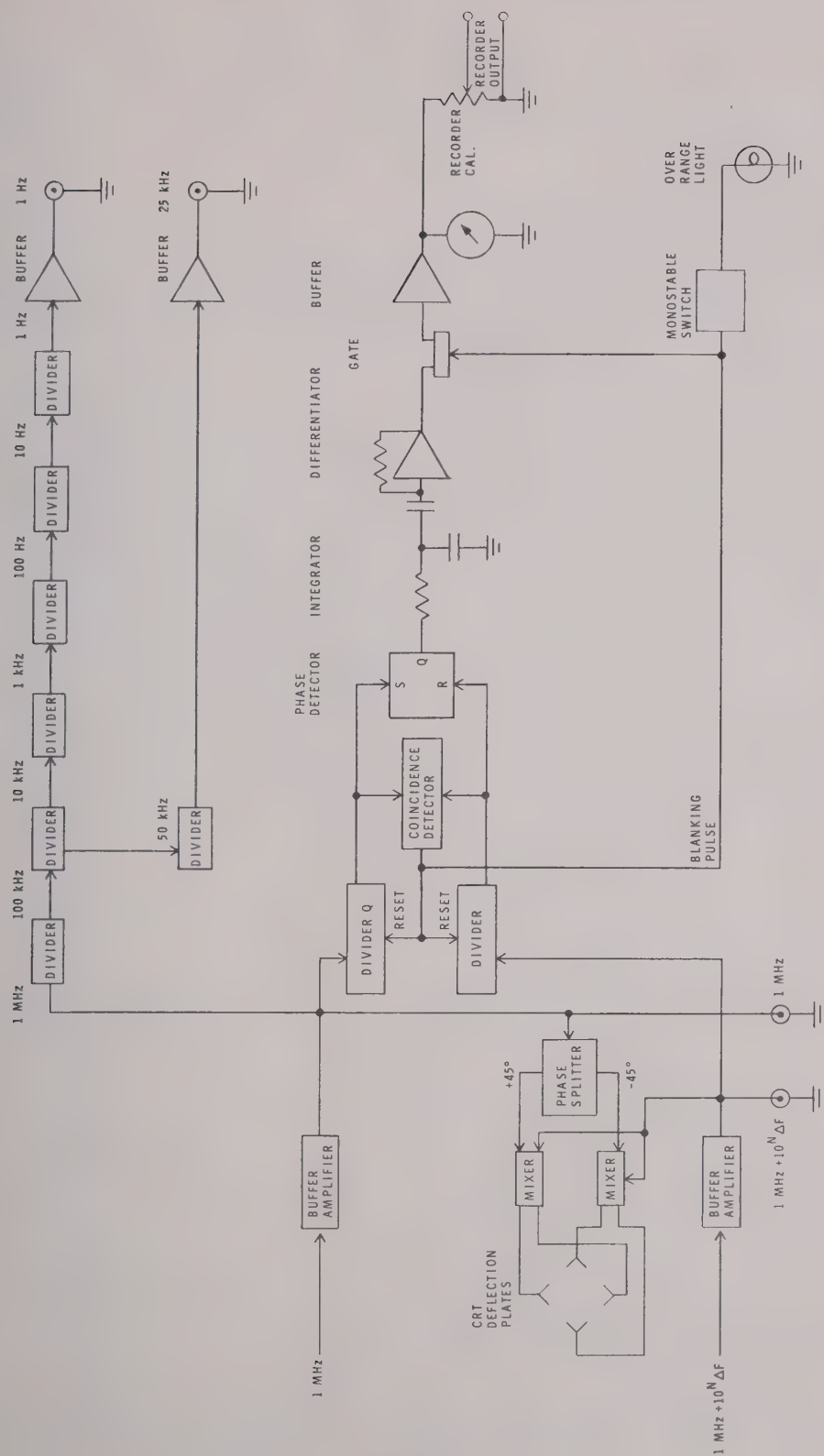


Figure 4-4. Block Diagram of Metering and Display Circuitry

SECTION V

MAINTENANCE, TROUBLESHOOTING AND CALIBRATION

5-1. INTRODUCTION.

5-2. This section deals with preventive maintenance operations, such as periodic cleaning, inspection, and brief operation checks; with corrective maintenance procedures such as fault isolation and field repair; and with calibration procedures associated with this instrument.

5-3. PREVENTIVE MAINTENANCE.

5-4. The Hickok FDM2100 has been designed for years of trouble-free operation but, like any precision instrument, will require periodic cleaning and inspection. At six-month intervals the top and bottom covers should be removed and the unit should be inspected for discolored areas and heavy accumulations of dust and dirt which may have resulted from operation in a nonclean environment. Inspect the range switch to ascertain that the shaft moves freely and lubricate if necessary; inspect the switch contacts for signs of corrosion and act accordingly. The CRT face should be kept clean, as should the meter window. The meter window has been treated at the factory with a compound which minimizes buildup of static charge. This compound has been applied to the inside of the window as well as to the outside. The outside of the meter should be

cleaned with a soft, dry cloth or compressed air, avoiding use of all solvents, including soap and water. If it becomes necessary to clean the plastic meter window, use a lukewarm soap and water solution and, after cleaning, treat the window with a high-grade commercial antistatic compound. At six-month intervals the FDM2100 should be checked for accuracy and proper operation. This can best be accomplished by the use of two high-quality signal sources. A quick check can be accomplished by comparing the meter reading with the fractional frequency difference obtained by timing oscilloscope display rotations. If this cursory check reveals that the FDM2100 is either out of tolerance on meter accuracy or is insensitive to some combinations of input frequencies, a complete calibration should be effected in accordance with paragraph 5-8 or by effecting a partial calibration if the procedures of paragraph 5-6 have isolated the difficulty to one or two specific assemblies.

5-5. CORRECTIVE MAINTENANCE.

5-6. Table 5-1 provides a check list for determining proper operation as well as providing a means for associating a given malfunction with a specific portion of the circuitry.

Table 5-1. Maintenance Check List

Symptom	Assembly	Possible diagnosis/remedy
Pilot light does not glow		Check for power switch ON, line cord connected, plug-in fuse continuity, pilot light failure.
Pilot light on; unit not functional	A13, 14, 15	Check for proper DC voltages at the extender board (A12) in accordance with paragraph 4-13.
No raster on CRT display	A14, A11	Check for presence of 1 MHz and $1 \text{ MHz} + 10^N \Delta F$ signals at the front panel jacks. Both signals should exceed 100 mV RMS. Check CRT cathode potential (-200 to -350 VDC). If missing, trace backward to assembly A14. Check vertical and horizontal deflection plate voltages. Voltages should average to zero at both sets of plates. If not, check scope drivers on assembly A11.
1 MHz and $1 \text{ MHz} + 10^N \Delta F$ signals not present at front panel jacks	A1, 2 (1 MHz); A3-A7 (1 MHz + $10^N \Delta F$); A8 (both)	Check for proper input signal by applying input signals to front panel input jacks and reading between 0.5 and 10V RMS at the rear panel input jacks.

Table 5-1. Maintenance Check List (Cont.)

Symptom	Assembly	Possible diagnosis/remedy
1 MHz and 1 MHz + $10^N \Delta F$ signals not present at front panel jacks (Cont.)	A9	Check frequency of input signals with high frequency counter to determine compliance with bandwidth requirements.
1 Hz and 25 kHz output signals not present at front panel jacks		Check 1 MHz and 1 MHz + $10^N \Delta F$ inputs to assembly A8. If fault is still unremedied, recalibrate assemblies A1 through A7. Check for 1 MHz reference signal input to assembly A9. Check for proper divide-by-ten action of the integrated circuit decade counters (1 Hz) and also for proper divide-by-two action of integrated circuit A9IC7.

5-7. Once a fault has been isolated to the component level it is important to follow good industrial practice in replacing the component. In particular, avoid applying excessive heat to any semiconductor, including integrated circuits, and after component replacement the printed circuit board should be cleaned of all residue (flux, etc.). As a general rule, when components are replaced on assemblies A1 through A7, A10 or A11, the calibration procedures associated with these assemblies must be executed. When in doubt, check for conformance to the operational specifications of paragraph 1-6 before performing recalibration.

5-8. CALIBRATION.

5-9. Complete calibration should be performed on an annual basis and inspection for conformance with the specifications of paragraph 1-6 should be performed on a semiannual basis. The following calibration procedure has been written with the assumption that high-quality laboratory equipment is available and that calibration will be performed either by an experienced instrumentation technician or by an engineer.

WARNING

When removing or inserting plug-in assemblies, be sure unit is turned off.

a. Preliminary Calibration of Tuned Amplifiers and Multipliers. Remove the shield plates covering the printed circuit boards. This will include four Error Multiplier boards (A3, A4, A6, A7), the Reference Input board (A2), and the Divider board (A1).

1. Connect a stable 1 MHz source to REF INPUT connector. Do not connect anything to the TEST INPUT connector.

2. Set TEST/OPERATE switch to TEST.

3. Set FILTER switch to OUT.

4. The Power Supply Regulator Assembly (A13) and shield should be placed in connector X13. All other boards should be removed.

5. Place the PCB extender (A12) in connector X2 and connect Reference Input Assembly (A2) to PCB extender.

6. Placing a X10 scope probe to the secondary of A2T2, observe a 5 MHz sine wave.

7. Adjust A2T2 for maximum amplitude (peak-to-peak) of 5 MHz sine wave.

NOTE

If resonance of tank at proper circuit frequency cannot be achieved by tuning or if both sides of the resonance curve cannot be observed, calibration capacitors may be necessary.

8. Place the probe on the secondary of A2T2 and adjust for maximum 5 MHz sine wave.

9. Remove A2 from PCB and place A2 in X2.

10. Place PCB extender in X1.

11. Place 5 MHz/1 MHz Divider Assembly (A1) in PCB extender. With the Reference Input board removed and the Divider inserted in X1, check the secondary of A1T3 for a 4 MHz sine wave generated by the free-running oscillator (Q9). This oscillator should be free running at approximately 4 MHz.

12. Looking at the secondary of A1T1, adjust for maximum 5 MHz sine wave.

13. Adjust A1T3 for maximum 4 MHz sine wave.

14. Adjust A1T2 for maximum 1 MHz sine wave.

15. Adjust A1T4 for maximum 1 MHz sine wave.

16. Remove Divider from PCB extender and insert Divider in X1.

17. Again place the Reference Input Assembly A2 in the PCB extender and insert in connector X2.

18. Adjust T3, T4 and T5 of A2 for maximum 9 MHz sine wave.

19. Remove Reference Input board from PCB extender and insert in X2.

20. Place first Error Multiplier Assembly (A3) in PCB extender and insert in connector X3.

21. Place the scope probe on secondaries of A3T2 and A3T3 and adjust for maximum 10 MHz damped sine wave.

22. Adjust A3T4 for maximum 9 MHz and adjust T5, T6 and T7 of A3 for maximum 1 MHz sine wave.

23. Continue with the previous step for the three remaining Error Multiplier Boards.

b. Calibration of Amplifiers. Set up as follows: Connect 1 MHz reference to REF INPUT connector. Place TEST/OPERATE switch in TEST position. Place 4 ERROR MULT., REF INPUT, Power Supplies Regulator and Divider Assemblies, complete with shield assemblies, in the proper connectors. Then proceed as follows:

1. Adjust transformers T2 and T3 on the Reference Input board A2 and transformer T1 on Divider board A1 for minimum DC voltage at TP1 on the Divider board.

2. Adjust T2 on the Divider board for minimum DC voltage at TP2.

3. Adjust T3 on the Divider board for minimum DC voltage at TP3.

4. Adjust transformer T4 on the Divider board for minimum DC voltage at TP4.

5. Reinsert the Divider board in the unit and place the Reference Input board on the extender.

6. Adjust T4, T5 and T6 on the Reference Input Assembly A2 for minimum DC voltage at TP1.

7. Reinsert the Reference Input board and place the 1st Error Multiplier Assembly A3 on the extender board.

8. Set TEST/OPERATE switch to OPERATE. Adjust A3T4 for maximum 9 MHz at TP1. Set TEST/OPERATE switch to TEST.

9. Adjust A3T2 and A3T3 for a maximum 1 MHz envelope at TP1.

10. Connect 100 kHz to the REF INPUT. Readjust A3T2 and A3T3 for maximum 1 MHz envelope.

11. Connect 5 MHz to the REF INPUT. Adjust to obtain the best balance between the 1 MHz envelope when 100 kHz and 5 MHz are alternately applied to the REF INPUT.

12. Connect REF INPUT to 1 MHz. Adjust T5, T6 and T7 of A3 for maximum DC voltage at TP2.

13. Place the 1st Error Multiplier back in its proper location. Place the 2nd Error Multiplier on the extender board. Adjust the remaining Error Multipliers as the 1st, using steps 8, 9 and 12.

14. Place the XTAL Filter Assembly A5 on the extender. With a 10:1 scope probe connected to Pin 5 of the connector, X5, adjust C2 of A5 for maximum 1 MHz signal.

15. Insert all assemblies into their proper connectors.

c. Calibration of Scope Driver.

1. With a TEST INPUT frequency of 1 MHz and a REF INPUT frequency of 1 MHz connected, adjust the frequency difference so that the spot rotation appears to be a continuous trace.

2. Adjust R20, R22 and R7 to obtain a circular trace.

3. Adjust R8 and R30 to center the trace on the screen.

4. Adjust the front panel radius for desired circle diameter.

d. Meter Calibration.

1. Connect signals to the REF INPUT and TEST INPUT whose frequencies can be offset of the order of 9 parts in 10^9 or greater.

2. Offset the frequencies either 9 parts in 10^9 or 9 parts in 10^8 .

3. Set the Meter Range switch to the appropriate range. Adjust R9 for a reading of 9 on the meter.

4. Set Meter Range switch to the 10^7 range. Offset the frequency sources by 9 parts in 10^7 .

5. Adjust R14 for a reading of 9.

SECTION VI

PARTS LIST

6-1. INTRODUCTION.

6-2. Information is provided in this section to identify individual parts in the equipment and its various subassemblies for ordering maintenance parts and, when used in conjunction with the schematic diagrams and illustrations in section VII, for locating the parts within the equipment. Reference designations have been assigned in the following manner to aid in locating the individual parts in the various subassemblies of the equipment.

6-3. Basic reference designations such as C1, R2, Q4, etc., are assigned to the parts within a subassembly. A prefix designation is assigned to each of the subassemblies A1 through A15. The prefix designation for a given subassembly in combination with basic reference designation of a part within the subassembly provides the complete reference designation for that particular part. For example: A1C1, A1R2, and A1Q4 are the complete reference designations for capacitor C1, resistor R2 and transistor Q4 in subassembly A1.

6-4. Parts associated with the main chassis and panel assembly of the equipment are identified by the use of basic reference designations only without any prefix. Examples: E1, J1, and T1.

6-5. Sockets associated with a particular plug-in device such as a subassembly, electron tube, fuse or lamp are identified by a basic reference designation which includes the reference designation of the plug-in device. For example: XA1, XV1, XF1, and XDS1.

6-6. MAINTENANCE PARTS LIST.

6-7. Table 6-1 lists all maintenance parts for the equipment. The first column lists the reference designations in alpha-numeric sequence. The second column refers to explanatory or instructional notes which may appear in paragraph 6-10 below. The

third column gives the name and a brief description of all key parts (parts differing from any part previously listed in the table). The name and description are omitted for other parts and the notation "Same as (followed by the reference designation of the corresponding key part)" is substituted. The fourth column lists the Hickok Electrical Instrument Company's part number for the part. The fifth column lists the five-digit code number of the manufacturer of the part. (These code numbers are cross referenced to the manufacturer's name and address in table 6-2.) The sixth column lists the manufacturer's part number if different from the Hickok part number. The seventh column indicates the illustration on which the part may be located. The last column lists the total quantity of the key parts used in the equipment.

6-8. LIST OF MANUFACTURERS.

6-9. Table 6-2 lists the manufacturers of parts used in the equipment. The first column lists the five-digit Federal Supply Code for Manufacturer's number which also appears in the fifth column of table 6-1. The second column gives the name and address of each manufacturer.

6-10. NOTES.

6-11. Additional information about items listed in table 6-1 is provided by the following notes.

Note a. Replacement plug-in assembly supplied complete with shield.

Note b. This capacitor may be omitted or its value may vary in some equipments due to calibration requirements of the individual equipment. Value shown in parts list is nominal. If replacement is necessary, use same value as original part.

Note c. The value of this resistor may vary in some equipments due to calibration requirements. Replace with same value as original parts.

FDM2100

Table 6-1. Maintenance Parts List

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A1	a	MODULE ASSEMBLY: divider 5MC 1MC	13630-904	28569		7-2, 7-15	1
A1C1		CAPACITOR, FIXED, MICA: 220 pf, 2%, 500V	3095-289	81349	CM05FD221G03	7-2, 7-15	21
A1C2		CAPACITOR, FIXED, METAL- LIZED, POLYESTER FILM: 0.1 uf, 10%, 200V	3092-213	73445	C2080AE/A100K	7-2, 7-15	19
A1C3		CAPACITOR, FIXED, CERAMIC: 0.01 uf, 50V	3110-308	56289	TG-S10	7-2, 7-15	47
A1C4	b	CAPACITOR, FIXED, MICA: 5 pf $\pm$ 0.5 pf, 500V	3095-274	81349	CM05CD050D03	7-2, 7-15	1
A1C5		CAPACITOR, FIXED, MICA: 100 pf, 2%, 500V	3095-276	81349	CM05FD101G03	7-2, 7-15	5
A1C6		Same as A1C1				7-2, 7-15	
A1C7		Same as A1C1				7-2, 7-15	
A1C8		Same as A1C1				7-2, 7-15	
A1C9		Same as A1C1				7-2, 7-15	
A1C10		CAPACITOR, FIXED, MICA: 560 pf, 2%	3095-282	84171	DM-15-561G	7-2, 7-15	10
A1C11		Same as A1C3				7-2, 7-15	
A1C12	b	CAPACITOR, FIXED, MICA: 39 pf, 2%, 500V	3095-290	81349	CM05ED390G03	7-2, 7-15	10
A1C13		Same as A1C3				7-2, 7-15	
A1C14		Same as A1C1				7-2, 7-15	
A1C15		Same as A1C1				7-2, 7-15	
A1C16	b	CAPACITOR, FIXED, MICA: 15 pf $\pm$ 0.5 pf	3095-280	84171	DM-15-150	7-2, 7-15	5
A1C17		CAPACITOR, FIXED, MICA: 130 pf, 2%, 500V	3095-286	81349	CM05FD131G03	7-2, 7-15	1
A1C18		CAPACITOR, FIXED, MICA: 91 pf, 2%, 500V	3095-293	81349	CM05FD910G03	7-2, 7-15	2
A1C19		CAPACITOR, FIXED, TANTA- LUM: 3.3 uf, 10%, 15V	3085-369	31433	CSR13D335KL	7-2, 7-15	6
A1C20		Same as A1C10				7-2, 7-15	
A1C21	b	Same as A1C12				7-2, 7-15	
A1C22		Same as A1C3				7-2, 7-15	
A1C23		Same as A1C3				7-2, 7-15	
A1C24		Same as A1C1				7-2, 7-15	
A1CR1		SEMICONDUCTOR DEVICE: diode 1N914	3870-175	01295	1N914	7-2, 7-15	43
A1CR2		Same as A1CR1				7-2, 7-15	
A1CR3		Same as A1CR1				7-2, 7-15	
A1CR4		Same as A1CR1				7-2, 7-15	
A1Q1		TRANSISTOR: MPS3646-5	20861-263	04713	MPS3646-5	7-2, 7-15	50
A1Q2		Same as A1Q1				7-2, 7-15	
A1Q3		Same as A1Q1				7-2, 7-15	
A1Q4		Same as A1Q1				7-2, 7-15	
A1Q5		Same as A1Q1				7-2, 7-15	
A1Q6		Same as A1Q1				7-2, 7-15	
A1Q7		Same as A1Q1				7-2, 7-15	
A1Q8		Same as A1Q1				7-2, 7-15	
A1Q9		Same as A1Q1				7-2, 7-15	
A1Q10		TRANSISTOR: 2N3705	20861-259	01295	2N3705	7-2, 7-15	31
A1Q11		Same as A1Q10				7-2, 7-15	
A1R1		RESISTOR, FIXED, COMPOSI- TION: 10 ohms, 10%, 1/4W	X18450-102	81349	RC07GF100K	7-2, 7-15	6
A1R2		RESISTOR, FIXED, COMPOSI- TION: 47K ohms, 10%, 1/4W	X18453-472	81349	RC07GF473K	7-2, 7-15	14
A1R3		RESISTOR, FIXED, COMPOSI- TION: 15K ohms, 10%, 1/4W	X18453-152	81349	RC07GF153K	7-2, 7-15	1

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A1R4		RESISTOR, FIXED, COMPOSITION: 470 ohms, 10%, 1/4W	X18451-472	81349	RC07GF471K	7-2, 7-15	9
A1R5		RESISTOR, FIXED, COMPOSITION: 2.7K ohms, 10%, 1/4W	X18452-272	81349	RC07GF272K	7-2, 7-15	8
A1R6		RESISTOR, FIXED, COMPOSITION: 100 ohms, 10%, 1/4W	X18451-102	81349	RC07GF101K	7-2, 7-15	25
A1R7		RESISTOR, FIXED, COMPOSITION: 220K ohms, 10%, 1/4W	X18454-222	81349	RC07GF224K	7-2, 7-15	2
A1R8		Same as A1R6				7-2, 7-15	
A1R9		RESISTOR, FIXED, COMPOSITION: 220 ohms, 10%, 1/4W	X18451-222	81349	RC07GF221K	7-2, 7-15	12
A1R10		Same as A1R6				7-2, 7-15	
A1R11		Same as A1R7				7-2, 7-15	
A1R12		Same as A1R2				7-2, 7-15	
A1R13		Same as A1R6				7-2, 7-15	
A1R14		Same as A1R2				7-2, 7-15	
A1R15		Same as A1R6				7-2, 7-15	
A1R16		Same as A1R2				7-2, 7-15	
A1R17		Same as A1R2				7-2, 7-15	
A1R18		Same as A1R2				7-2, 7-15	
A1R19		Same as A1R2				7-2, 7-15	
A1R20		Same as A1R9				7-2, 7-15	
A1R21		RESISTOR, FIXED, COMPOSITION: 68 ohms, 10%, 1/4W	X18450-682	81349	RC07GF680K	7-2, 7-15	1
A1R22		RESISTOR, FIXED, COMPOSITION: 68K ohms, 10%, 1/4W	X18453-682	81349	RC07GF683K	7-2, 7-15	1
A1R23		RESISTOR, FIXED, COMPOSITION: 1K ohms, 10%, 1/4W	X18452-102	81349	RC07GF102K	7-2, 7-15	21
A1R24		RESISTOR, FIXED, COMPOSITION: 27K ohms, 10%, 1/4W	X18453-272	81349	RC07GF273K	7-2, 7-15	3
A1R25		Same as A1R2				7-2, 7-15	
A1R26		Same as A1R5				7-2, 7-15	
A1R27		RESISTOR, FIXED, COMPOSITION: 10K ohms, 10%, 1/4W	X18453-102	81349	RC07GF103K	7-2, 7-15	14
A1R28		Same as A1R9				7-2, 7-15	
A1T1		TRANSFORMER: R.F., 16:4 CT turns ratio	20800-382	28569		7-2, 7-15	2
A1T2		TRANSFORMER: R.F., 32.8 CT turns ratio	20800-384	28569		7-2, 7-15	1
A1T3		Same as A1T1				7-2, 7-15	
A1T4		TRANSFORMER: 32.4 turns ratio	20800-383	28569		7-2, 7-15	13
A2	a	MODULE ASSEMBLY: reference input	13630-903	28569		7-3, 7-16	1
A2C1		Same as A1C2				7-3, 7-16	
A2C2		CAPACITOR, FIXED, CERAMIC: 2200 pf, 1000V	3110-307	71590	DD222	7-3, 7-16	1
A2C3		Same as A1C3				7-3, 7-16	
A2C4		Same as A1C3				7-3, 7-16	
A2C5		Same as A1C3				7-3, 7-16	
A2C6		Same as A1C19				7-3, 7-16	
A2C7		CAPACITOR, FIXED, MICA: 160 pf, 2%, 500V	3095-287	81349	CM05FD161G03	7-3, 7-16	1
A2C8		Same as A1C3				7-3, 7-16	
A2C9	b	CAPACITOR, FIXED, MICA: 3 pf $\pm$ 0.5 pf	3095-284	53021	Type D15	7-3, 7-16	2
A2C10		Same as A1C18				7-3, 7-16	
A2C11		CAPACITOR, FIXED, MICA: 10 pf $\pm$ 0.5 pf, 500V	3095-273	81349	CM05CD100D03	7-3, 7-16	14

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A2C12		CAPACITOR, FIXED, MICA: 82 pf, 2%, 500V	3095-292	81349	CM05ED820G03	7-3, 7-16	9
A2C13		Same as A1C2				7-3, 7-16	
A2C14		Same as A1C5				7-3, 7-16	
A2C15		Same as A1C5				7-3, 7-16	
A2C16		Same as A2C9				7-3, 7-16	
A2C17		Same as A2C11				7-3, 7-16	
A2C18		Same as A1C3				7-3, 7-16	
A2C19		Same as A1C3				7-3, 7-16	
A2C20		CAPACITOR, FIXED, MICA: 110 pf, 2%, 500V	3095-285	81349	CM05FD111G03	7-3, 7-16	5
A2CR1		Same as A1CR1				7-3, 7-16	
A2CR2		Same as A1CR1				7-3, 7-16	
A2CR3		Same as A1CR1				7-3, 7-16	
A2CR4		Same as A1CR1				7-3, 7-16	
A2CR5		Same as A1CR1				7-3, 7-16	
A2Q1		Same as A1Q1				7-3, 7-16	
A2Q2		Same as A1Q1				7-3, 7-16	
A2Q3		Same as A1Q1				7-3, 7-16	
A2Q4		Same as A1Q1				7-3, 7-16	
A2Q5		Same as A1Q10				7-3, 7-16	
A2Q6		Same as A1Q1				7-3, 7-16	
A2R1		Same as A1R1				7-3, 7-16	
A2R2		NOT ASSIGNED				7-3, 7-16	
A2R3		RESISTOR, FIXED, COMPOSI- TION: 150 ohms, 10%, 1/4W	X18451-152	81349	RC07GF151K	7-3, 7-16	10
A2R4		RESISTOR, FIXED, COMPOSI- TION: 4.7K ohms, 10%, 1/4W	X18452-472	81349	RC07GF472K	7-3, 7-16	14
A2R5		RESISTOR, FIXED, COMPOSI- TION: 1.2K ohms, 10%, 1/4W	X18452-122	81349	RC07GF122K	7-3, 7-16	8
A2R6		RESISTOR, FIXED, COMPOSI- TION: 680 ohms, 10%, 1/4W	X18451-682	81349	RC07GF681K	7-3, 7-16	8
A2R7		Same as A2R3				7-3, 7-16	
A2R8		Same as A2R4				7-3, 7-16	
A2R9		RESISTOR, FIXED, COMPOSI- TION: 6.8K ohms, 10%, 1/4W	X18452-682	81349	RC07GF682K	7-3, 7-16	12
A2R10		Same as A2R9				7-3, 7-16	
A2R11		RESISTOR, FIXED, COMPOSI- TION: 2.2K ohms, 10%, 1/4W	X18452-222	81349	RC07GF222K	7-3, 7-16	17
A2R12		Same as A1R23				7-3, 7-16	
A2R13		Same as A1R1				7-3, 7-16	
A2R14		RESISTOR, FIXED, COMPOSI- TION: 560 ohms, 10%, 1/4W	X18451-562	81349	RC07GF561K	7-3, 7-16	5
A2R15		RESISTOR, FIXED, COMPOSI- TION: 33K ohms, 10%, 1/4W	X18453-332	81349	RC07GF333K	7-3, 7-16	1
A2R16		Same as A1R1				7-3, 7-16	
A2R17		RESISTOR, FIXED, COMPOSI- TION: 3.9K ohms, 10%, 1/4W	X18452-392	81349	RC07GF392K	7-3, 7-16	6
A2R18		Same as A2R11				7-3, 7-16	
A2R19		Same as A1R9				7-3, 7-16	
A2R20		RESISTOR, FIXED, COMPOSI- TION: 150K, ohms, 10%, 1/4W	X18454-152	81349	RC07GF154K	7-3, 7-16	1
A2R21		Same as A1R6				7-3, 7-16	

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A2T1		NOT ASSIGNED				7-3, 7-16	
A2T2		TRANSFORMER: R.F., 16:2 turns ratio	20800-381	28569		7-3, 7-16	2
A2T3		Same as A2T2				7-3, 7-16	
A2T4		TRANSFORMER: R.F., 8:1 turns ratio	20800-380	28569		7-3, 7-16	15
A2T5		Same as A2T4				7-3, 7-16	
A2T6		Same as A2T4				7-3, 7-16	
A3	a	MODULE ASSEMBLY: 1st error multiplier	13630-905	28569		7-4, 7-17	1
A3C1		NOT ASSIGNED				7-4, 7-17	
A3C2		Same as A1C2				7-4, 7-17	
A3C3		Same as A1C3				7-4, 7-17	
A3C4		Same as A1C3				7-4, 7-17	
A3C5		Same as A1C19				7-4, 7-17	
A3C6		Same as A1C3				7-4, 7-17	
A3C7		Same as A1C1				7-4, 7-17	
A3C8		Same as A1C3				7-4, 7-17	
A3C9		Same as A2C12				7-4, 7-17	
A3C10		Same as A2C11				7-4, 7-17	
A3C11		Same as A2C12				7-4, 7-17	
A3C12		Same as A1C1				7-4, 7-17	
A3C13		Same as A1C2				7-4, 7-17	
A3C14		Same as A2C20				7-4, 7-17	
A3C15		CAPACITOR, FIXED, MICA: 680 pf, 2%	3095-283	84171	DM-15-681G	7-4, 7-17	4
A3C16		Same as A1C1				7-4, 7-17	
A3C17		Same as A1C2				7-4, 7-17	
A3C18		Same as A1C10				7-4, 7-17	
A3C19		Same as A1C3				7-4, 7-17	
A3C20		CAPACITOR, FIXED, MICA: 75 pf, 2%, 500V	3095-291	81349	CM05ED750G03	7-4, 7-17	4
A3C21		CAPACITOR, FIXED, MICA: 510 pf, 2%	3095-281	84171	DM-15-511G	7-4, 7-17	4
A3C22		Same as A1C3				7-4, 7-17	
A3C23		Same as A1C3				7-4, 7-17	
A3C24		NOT ASSIGNED				7-4, 7-17	
A3C25	b	Same as A1C12				7-4, 7-17	
A3C26		Same as A1C16				7-4, 7-17	
A3C27	b	Same as A1C12				7-4, 7-17	
A3C28		Same as A1C10				7-4, 7-17	
A3C29	b	Same as A2C11				7-4, 7-17	
A3C30	b	Same as A2C11				7-4, 7-17	
A3CR1		Same as A1CR1				7-4, 7-17	
A3CR2		Same as A1CR1				7-4, 7-17	
A3CR3		Same as A1CR1				7-4, 7-17	
A3CR4		Same as A1CR1				7-4, 7-17	
A3CR5		Same as A1CR1				7-4, 7-17	
A3Q1		Same as A1Q1				7-4, 7-17	
A3Q2		Same as A1Q1				7-4, 7-17	
A3Q3		Same as A1Q1				7-4, 7-17	
A3Q4		Same as A1Q1				7-4, 7-17	
A3Q5		Same as A1Q1				7-4, 7-17	
A3Q6		Same as A1Q1				7-4, 7-17	
A3Q7		Same as A1Q10				7-4, 7-17	
A3Q8		Same as A1Q10				7-4, 7-17	
A3R1		Same as A1R23				7-4, 7-17	
A3R2		Same as A1R6				7-4, 7-17	
A3R3		Same as A1R6				7-4, 7-17	
A3R4		Same as A2R3				7-4, 7-17	

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A3R5		Same as A2R6				7-4, 7-17	
A3R6		Same as A2R5				7-4, 7-17	
A3R7		Same as A2R4				7-4, 7-17	
A3R8		Same as A2R3				7-4, 7-17	
A3R9		Same as A2R4				7-4, 7-17	
A3R10		RESISTOR, FIXED, COMPOSITION: 3.3K ohms, 10%, 1/4W	X18452-332	81349	RC07GF332K	7-4, 7-17	17
A3R11		Same as A3R10				7-4, 7-17	
A3R12		Same as A2R11				7-4, 7-17	
A3R13		Same as A1R23				7-4, 7-17	
A3R14		Same as A1R1				7-4, 7-17	
A3R15		Same as A2R14				7-4, 7-17	
A3R16		RESISTOR, FIXED, COMPOSITION: 18K ohms, 10%, 1/4W	X18453-182	81349	RC07GF183K	7-4, 7-17	8
A3R17		Same as A1R6				7-4, 7-17	
A3R18		Same as A2R9				7-4, 7-17	
A3R19		Same as A1R9				7-4, 7-17	
A3R20		Same as A3R10				7-4, 7-17	
A3R21		Same as A2R11				7-4, 7-17	
A3R22		RESISTOR, FIXED, COMPOSITION: 390 ohms, 10%, 1/4W	X18451-392	81349	RC07GF391K	7-4, 7-17	4
A3R23		Same as A1R27				7-4, 7-17	
A3R24		Same as A1R23				7-4, 7-17	
A3R25		Same as A2R9				7-4, 7-17	
A3R26		Same as A3R10				7-4, 7-17	
A3R27		Same as A3R16				7-4, 7-17	
A3R28		Same as A2R17				7-4, 7-17	
A3R29		Same as A2R11				7-4, 7-17	
A3R30		RESISTOR, FIXED, COMPOSITION: 390K ohms, 10%, 1/4W	X18454-392	81349	RC07GF394K	7-4, 7-17	4
A3R31		Same as A1R9				7-4, 7-17	
A3R32		RESISTOR, FIXED, COMPOSITION: 120 ohms, 10%, 1/4W	X18451-122	81349	RC07GF121K	7-4, 7-17	4
A3T1		NOT ASSIGNED				7-4, 7-17	
A3T2		Same as A2T4				7-4, 7-17	
A3T3		Same as A2T4				7-4, 7-17	
A3T4		Same as A2T4				7-4, 7-17	
A3T5		Same as A1T4				7-4, 7-17	
A3T6		Same as A1T4				7-4, 7-17	
A3T7		Same as A1T4				7-4, 7-17	
A4	a	MODULE ASSEMBLY: 2nd error multiplier	13630-906	28569		7-4, 7-18	3
A4C1		NOT ASSIGNED				7-4, 7-18	
A4C2		Same as A1C2				7-4, 7-18	
A4C3		Same as A1C3				7-4, 7-18	
A4C4		Same as A1C3				7-4, 7-18	
A4C5		Same as A1C19				7-4, 7-18	
A4C6		Same as A1C3				7-4, 7-18	
A4C7		Same as A1C1				7-4, 7-18	
A4C8		Same as A1C3				7-4, 7-18	
A4C9		Same as A2C12				7-4, 7-18	
A4C10		Same as A2C11				7-4, 7-18	
A4C11		Same as A2C12				7-4, 7-18	
A4C12		Same as A1C1				7-4, 7-18	
A4C13		Same as A1C2				7-4, 7-18	

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A4C14		Same as A2C20				7-4, 7-18	
A4C15		Same as A3C15				7-4, 7-18	
A4C16		Same as A1C1				7-4, 7-18	
A4C17		Same as A1C2				7-4, 7-18	
A4C18		Same as A1C10				7-4, 7-18	
A4C19		Same as A1C3				7-4, 7-18	
A4C20		Same as A3C20				7-4, 7-18	
A4C21		Same as A3C21				7-4, 7-18	
A4C22		Same as A1C3				7-4, 7-18	
A4C23		Same as A1C3				7-4, 7-18	
A4C24		NOT ASSIGNED				7-4, 7-18	
A4C25	b	Same as A1C12				7-4, 7-18	
A4C26		Same as A1C16				7-4, 7-18	
A4C27	b	Same as A1C12				7-4, 7-18	
A4C28		Same as A1C10				7-4, 7-18	
A4C29	b	Same as A2C11				7-4, 7-18	
A4C30	b	Same as A2C11				7-4, 7-18	
A4CR1		NOT ASSIGNED				7-4, 7-18	
A4CR2		NOT ASSIGNED				7-4, 7-18	
A4CR3		Same as A1CR1				7-4, 7-18	
A4CR4		Same as A1CR1				7-4, 7-18	
A4CR5		Same as A1CR1				7-4, 7-18	
A4Q1		Same as A1Q1				7-4, 7-18	
A4Q2		Same as A1Q1				7-4, 7-18	
A4Q3		Same as A1Q1				7-4, 7-18	
A4Q4		Same as A1Q1				7-4, 7-18	
A4Q5		Same as A1Q1				7-4, 7-18	
A4Q6		Same as A1Q1				7-4, 7-18	
A4Q7		Same as A1Q10				7-4, 7-18	
A4Q8		Same as A1Q10				7-4, 7-18	
A4R1		NOT ASSIGNED				7-4, 7-18	
A4R2		Same as A1R6				7-4, 7-18	
A4R3		Same as A1R6				7-4, 7-18	
A4R4		Same as A2R3				7-4, 7-18	
A4R5		Same as A2R6				7-4, 7-18	
A4R6		Same as A2R5				7-4, 7-18	
A4R7		Same as A2R4				7-4, 7-18	
A4R8		Same as A2R3				7-4, 7-18	
A4R9		Same as A2R4				7-4, 7-18	
A4R10		Same as A3R10				7-4, 7-18	
A4R11		Same as A3R10				7-4, 7-18	
A4R12		Same as A1R27				7-4, 7-18	
A4R13		Same as A1R23				7-4, 7-18	
A4R14		Same as A1R6				7-4, 7-18	
A4R15		Same as A2R14				7-4, 7-18	
A4R16		Same as A3R16				7-4, 7-18	
A4R17		Same as A1R6				7-4, 7-18	
A4R18		Same as A2R9				7-4, 7-18	
A4R19		Same as A1R9				7-4, 7-18	
A4R20		Same as A3R10				7-4, 7-18	
A4R21		Same as A2R11				7-4, 7-18	
A4R22		Same as A3R22				7-4, 7-18	
A4R23		Same as A1R27				7-4, 7-18	
A4R24		Same as A1R23				7-4, 7-18	
A4R25		Same as A2R9				7-4, 7-18	
A4R26		Same as A3R10				7-4, 7-18	
A4R27		Same as A3R16				7-4, 7-18	
A4R28		Same as A2R17				7-4, 7-18	
A4R29		Same as A2R11				7-4, 7-18	
A4R30		Same as A3R30				7-4, 7-18	

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A4R31		Same as A1R9				7-4, 7-18	
A4R32		Same as A3R32				7-4, 7-18	
A4T1		NOT ASSIGNED				7-4, 7-18	
A4T2		Same as A2T4				7-4, 7-18	
A4T3		Same as A2T4				7-4, 7-18	
A4T4		Same as A2T4				7-4, 7-18	
A4T5		Same as A1T4				7-4, 7-18	
A4T6		Same as A1T4				7-4, 7-18	
A4T7		Same as A1T4				7-4, 7-18	
A5	a	MODULE ASSEMBLY: Crystal filter	13630-907	28569		7-5, 7-19	1
A5C1		CAPACITOR, FIXED, MICA: 18 pf, 10%	3095-294	84171	DM-15-180K	7-5, 7-19	1
A5C2		CAPACITOR, VAR., GLASS: 0.8 - 30 pf	3115-82	73899	VC43GWY	7-5, 7-19	1
A5C3		CAPACITOR, FIXED, MICA: 200 pf, 2%, 500V	3095-288	81349	CM05FD201G03	7-5, 7-19	3
A5XY1		HOLDER: for crystal	8825-275	91506	8000-DG2	7-5, 7-19	1
A5Y1		CRYSTAL: 1000 kHz	3870-273	72982		7-5, 7-19	1
A6	a	(3rd error multiplier) Same as A4				7-4, 7-18	
A6C1		NOT ASSIGNED				7-4, 7-18	
A6C2		Same as A1C2				7-4, 7-18	
A6C3		Same as A1C3				7-4, 7-18	
A6C4		Same as A1C3				7-4, 7-18	
A6C5		Same as A1C19				7-4, 7-18	
A6C6		Same as A1C3				7-4, 7-18	
A6C7		Same as A1C1				7-4, 7-18	
A6C8		Same as A1C3				7-4, 7-18	
A6C9		Same as A2C12				7-4, 7-18	
A6C10		Same as A2C11				7-4, 7-18	
A6C11		Same as A2C12				7-4, 7-18	
A6C12		Same as A1C1				7-4, 7-18	
A6C13		Same as A1C2				7-4, 7-18	
A6C14		Same as A2C20				7-4, 7-18	
A6C15		Same as A3C15				7-4, 7-18	
A6C16		Same as A1C1				7-4, 7-18	
A6C17		Same as A1C2				7-4, 7-18	
A6C18		Same as A1C10				7-4, 7-18	
A6C19		Same as A1C3				7-4, 7-18	
A6C20		Same as A3C20				7-4, 7-18	
A6C21		Same as A3C21				7-4, 7-18	
A6C22		Same as A1C3				7-4, 7-18	
A6C23		Same as A1C3				7-4, 7-18	
A6C24		NOT ASSIGNED				7-4, 7-18	
A6C25	b	Same as A1C12				7-4, 7-18	
A6C26		Same as A1C16				7-4, 7-18	
A6C27	b	Same as A1C12				7-4, 7-18	
A6C28		Same as A1C10				7-4, 7-18	
A6C29	b	Same as A2C11				7-4, 7-18	
A6C30	b	Same as A2C11				7-4, 7-18	
A6CR1		NOT ASSIGNED				7-4, 7-18	
A6CR2		NOT ASSIGNED				7-4, 7-18	
A6CR3		Same as A1CR1				7-4, 7-18	
A6CR4		Same as A1CR1				7-4, 7-18	
A6CR5		Same as A1CR1				7-4, 7-18	
A6Q1		Same as A1Q1				7-4, 7-18	
A6Q2		Same as A1Q1				7-4, 7-18	
A6Q3		Same as A1Q1				7-4, 7-18	
A6Q4		Same as A1Q1				7-4, 7-18	

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A6Q5		Same as A1Q1				7-4, 7-18	
A6Q6		Same as A1Q1				7-4, 7-18	
A6Q7		Same as A1Q10				7-4, 7-18	
A6Q8		Same as A1Q10				7-4, 7-18	
A6R1		NOT ASSIGNED				7-4, 7-18	
A6R2		Same as A1R6				7-4, 7-18	
A6R3		Same as A1R6				7-4, 7-18	
A6R4		Same as A2R3				7-4, 7-18	
A6R5		Same as A2R6				7-4, 7-18	
A6R6		Same as A2R5				7-4, 7-18	
A6R7		Same as A2R4				7-4, 7-18	
A6R8		Same as A2R3				7-4, 7-18	
A6R9		Same as A2R4				7-4, 7-18	
A6R10		Same as A3R10				7-4, 7-18	
A6R11		Same as A3R10				7-4, 7-18	
A6R12		Same as A1R27				7-4, 7-18	
A6R13		Same as A1R23				7-4, 7-18	
A6R14		Same as A1R6				7-4, 7-18	
A6R15		Same as A2R14				7-4, 7-18	
A6R16		Same as A3R16				7-4, 7-18	
A6R17		Same as A1R6				7-4, 7-18	
A6R18		Same as A2R9				7-4, 7-18	
A6R19		Same as A1R9				7-4, 7-18	
A6R20		Same as A3R10				7-4, 7-18	
A6R21		Same as A2R11				7-4, 7-18	
A6R22		Same as A3R22				7-4, 7-18	
A6R23		Same as A1R27				7-4, 7-18	
A6R24		Same as A1R23				7-4, 7-18	
A6R25		Same as A2R9				7-4, 7-18	
A6R26		Same as A3R10				7-4, 7-18	
A6R27		Same as A3R16				7-4, 7-18	
A6R28		Same as A2R17				7-4, 7-18	
A6R29		Same as A2R11				7-4, 7-18	
A6R30		Same as A3R30				7-4, 7-18	
A6R31		Same as A1R9				7-4, 7-18	
A6R32		Same as A3R32				7-4, 7-18	
A6T1		NOT ASSIGNED				7-4, 7-18	
A6T2		Same as A2T4				7-4, 7-18	
A6T3		Same as A2T4				7-4, 7-18	
A6T4		Same as A2T4				7-4, 7-18	
A6T5		Same as A1T4				7-4, 7-18	
A6T6		Same as A1T4				7-4, 7-18	
A6T7		Same as A1T4				7-4, 7-18	
A7	a	(4th error multiplier) Same as A4				7-4, 7-18	
A7C1		NOT ASSIGNED				7-4, 7-18	
A7C2		Same as A1C2				7-4, 7-18	
A7C3		Same as A1C3				7-4, 7-18	
A7C4		Same as A1C3				7-4, 7-18	
A7C5		Same as A1C19				7-4, 7-18	
A7C6		Same as A1C3				7-4, 7-18	
A7C7		Same as A1C1				7-4, 7-18	
A7C8		Same as A1C3				7-4, 7-18	
A7C9		Same as A2C12				7-4, 7-18	
A7C10		Same as A2C11				7-4, 7-18	
A7C11		Same as A2C12				7-4, 7-18	
A7C12		Same as A1C1				7-4, 7-18	
A7C13		Same as A1C2				7-4, 7-18	
A7C14		Same as A2C20				7-4, 7-18	
A7C15		Same as A3C15				7-4, 7-18	

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A7C16		Same as A1C1				7-4, 7-18	
A7C17		Same as A1C2				7-4, 7-18	
A7C18		Same as A1C10				7-4, 7-18	
A7C19		Same as A1C3				7-4, 7-18	
A7C20		Same as A3C20				7-4, 7-18	
A7C21		Same as A3C21				7-4, 7-18	
A7C22		Same as A1C3				7-4, 7-18	
A7C23		Same as A1C3				7-4, 7-18	
A7C24		NOT ASSIGNED				7-4, 7-18	
A7C25	b	Same as A1C12				7-4, 7-18	
A7C26		Same as A1C16				7-4, 7-18	
A7C27	b	Same as A1C12				7-4, 7-18	
A7C28		Same as A1C10				7-4, 7-18	
A7C29	b	Same as A2C11				7-4, 7-18	
A7C30	b	Same as A2C11				7-4, 7-18	
A7CR1		NOT ASSIGNED				7-4, 7-18	
A7CR2		NOT ASSIGNED				7-4, 7-18	
A7CR3		Same as A1CR1				7-4, 7-18	
A7CR4		Same as A1CR1				7-4, 7-18	
A7CR5		Same as A1CR1				7-4, 7-18	
A7Q1		Same as A1Q1				7-4, 7-18	
A7Q2		Same as A1Q1				7-4, 7-18	
A7Q3		Same as A1Q1				7-4, 7-18	
A7Q4		Same as A1Q1				7-4, 7-18	
A7Q5		Same as A1Q1				7-4, 7-18	
A7Q6		Same as A1Q1				7-4, 7-18	
A7Q7		Same as A1Q10				7-4, 7-18	
A7Q8		Same as A1Q10				7-4, 7-18	
A7R1		NOT ASSIGNED				7-4, 7-18	
A7R2		Same as A1R6				7-4, 7-18	
A7R3		Same as A1R6				7-4, 7-18	
A7R4		Same as A2R3				7-4, 7-18	
A7R5		Same as A2R6				7-4, 7-18	
A7R6		Same as A2R5				7-4, 7-18	
A7R7		Same as A2R4				7-4, 7-18	
A7R8		Same as A2R3				7-4, 7-18	
A7R9		Same as A2R4				7-4, 7-18	
A7R10		Same as A3R10				7-4, 7-18	
A7R11		Same as A3R10				7-4, 7-18	
A7R12		Same as A1R27				7-4, 7-18	
A7R13		Same as A1R23				7-4, 7-18	
A7R14		Same as A1R6				7-4, 7-18	
A7R15		Same as A2R14				7-4, 7-18	
A7R16		Same as A3R16				7-4, 7-18	
A7R17		Same as A1R6				7-4, 7-18	
A7R18		Same as A2R9				7-4, 7-18	
A7R19		Same as A1R9				7-4, 7-18	
A7R20		Same as A3R10				7-4, 7-18	
A7R21		Same as A2R11				7-4, 7-18	
A7R22		Same as A3R22				7-4, 7-18	
A7R23		Same as A1R27				7-4, 7-18	
A7R24		Same as A1R23				7-4, 7-18	
A7R25		Same as A2R9				7-4, 7-18	
A7R26		Same as A3R10				7-4, 7-18	
A7R27		Same as A3R16				7-4, 7-18	
A7R28		Same as A2R17				7-4, 7-18	
A7R29		Same as A2R11				7-4, 7-18	
A7R30		Same as A3R30				7-4, 7-18	
A7R31		Same as A1R9				7-4, 7-18	
A7R32		Same as A3R32				7-4, 7-18	

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A7T1	a	NOT ASSIGNED	13630-908	28569		7-4, 7-18	1
A7T2		Same as A2T4				7-4, 7-18	
A7T3		Same as A2T4				7-4, 7-18	
A7T4		Same as A2T4				7-4, 7-18	
A7T5		Same as A1T4				7-4, 7-18	
A7T6		Same as A1T4				7-4, 7-18	
A7T7		Same as A1T4				7-4, 7-18	
A8		MODULE ASSEMBLY: buffer amplifier				7-6, 7-20	
A8C1		CAPACITOR, FIXED, TANTA- LUM: 39 uf, 10V	3085-387	31433	CS13BC396K	7-6, 7-20	1
A8C2		Same as A1C3	3085-384	01295	CS13BE106K	7-6, 7-20	4
A8C3		Same as A1C3				7-6, 7-20	
A8C4		CAPACITOR, FIXED, ELECTROLYTIC: 10 uf				7-6, 7-20	
A8C5		Same as A8C4				7-6, 7-20	
A8C6		Same as A1C3	20861-258	01295	2N3702	7-6, 7-20	4
A8C7		Same as A1C3				7-6, 7-20	
A8C8		Same as A1C3				7-6, 7-20	
A8CR1		Same as A1CR1				7-6, 7-20	
A8Q1		Same as A1Q10				7-6, 7-20	
A8Q2		TRANSISTOR: 2N3702				7-6, 7-20	
A8Q3		Same as A1Q10				7-6, 7-20	
A8Q4		Same as A1Q10				7-6, 7-20	
A8Q5		Same as A1Q10				7-6, 7-20	
A8Q6		Same as A1Q10				7-6, 7-20	
A8Q7		Same as A1Q10				7-6, 7-20	
A8Q8		Same as A1Q10				7-6, 7-20	
A8Q9		Same as A1Q10				7-6, 7-20	
A8R1		Same as A2R17	X18453-222	81349	RC07GF223K	7-6, 7-20	4
A8R2		Same as A1R2				7-6, 7-20	
A8R3		Same as A1R4				7-6, 7-20	
A8R4		Same as A2R5				7-6, 7-20	
A8R5		Same as A1R27				7-6, 7-20	
A8R6		NOT ASSIGNED				7-6, 7-20	
A8R7		Same as A2R4				7-6, 7-20	
A8R8		Same as A2R4				7-6, 7-20	
A8R9		Same as A2R5				7-6, 7-20	
A8R10		RESISTOR, FIXED, COMPOSI- TION: 22K ohms, 10%, 1/4W				7-6, 7-20	
A8R11	a	Same as A8R10	13630-910	28569		7-6, 7-20	1
A8R12		Same as A1R2				7-6, 7-20	
A8R13		Same as A2R6				7-6, 7-20	
A8R14		Same as A2R6				7-6, 7-20	
A8R15		Same as A1R2				7-6, 7-20	
A8R16		Same as A2R5				7-6, 7-20	
A8R17		Same as A8R10				7-6, 7-20	
A8R18		Same as A8R10				7-6, 7-20	
A8R19		Same as A2R4	3095-295	81349	CM06FD471G03	7-6, 7-20	1
A8R20		Same as A1R27				7-6, 7-20	
A8R21		NOT ASSIGNED				7-6, 7-20	
A8R22		Same as A2R4				7-6, 7-20	
A9		MODULE ASSEMBLY: countdown/comparator	13630-910	28569		7-7, 7-21	1
A9C1		Same as A1C5				7-7, 7-21	
A9C2		CAPACITOR, FIXED, MICA: 470 pf, 2%, 500V				7-7, 7-21	
A9C3		Same as A1C1				7-7, 7-21	
A9C4		Same as A1C5				7-7, 7-21	
A9C5		Same as A1C2				7-7, 7-21	

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A9C6		CAPACITOR, FIXED, MICA: 1000 pf, 5%, 500V	3097-549	81349	CM06FD102J03	7-7, 7-21	5
A9C7		CAPACITOR, FIXED, MICA: 22 pf, 5%, 500V	3097-509	81349	CM05ED220J03	7-7, 7-21	1
A9C8		CAPACITOR, FIXED, MYLAR: 0.47 uf, 10%, 80V	3090-88	56289	192P4749R8	7-7, 7-21	1
A9C9		Same as A1C2				7-7, 7-21	
A9CR1		Same as A1CR1				7-7, 7-21	
A9CR2		Same as A1CR1				7-7, 7-21	
A9IC1		INTEGRATED CIRCUIT: decade counter	9800-49	04713	MC880P	7-7, 7-21	6
A9IC2		Same as A9IC1				7-7, 7-21	
A9IC3		Same as A9IC1				7-7, 7-21	
A9IC4		Same as A9IC1				7-7, 7-21	
A9IC5		Same as A9IC1				7-7, 7-21	
A9IC6		Same as A9IC1				7-7, 7-21	
A9IC7		INTEGRATED CIRCUIT: dual J-K Flip-Flop	9800-51	04713	MC890P	7-7, 7-21	2
A9IC8		Same as A9IC7				7-7, 7-21	
A9Q1		Same as A1Q1				7-7, 7-21	
A9Q2		Same as A1Q1				7-7, 7-21	
A9Q3		Same as A1Q1				7-7, 7-21	
A9Q4		TRANSISTOR: 2N3566	20861-122	07263	2N3566	7-7, 7-21	2
A9Q5		Same as A9Q4				7-7, 7-21	
A9Q6		TRANSISTOR: 2N5139	20861-181	07263	2N5139	7-7, 7-21	1
A9Q7		Same as A1Q1				7-7, 7-21	
A9Q8		Same as A1Q1				7-7, 7-21	
A9Q9		Same as A1Q1				7-7, 7-21	
A9Q10		Same as A1Q1				7-7, 7-21	
A9Q11		Same as A8Q2				7-7, 7-21	
A9Q12		Same as A1Q1				7-7, 7-21	
A9Q13		TRANSISTOR: 2N3904	20861-141	04713	2N3904	7-7, 7-21	1
A9R1		Same as A1R5				7-7, 7-21	
A9R2		Same as A1R5				7-7, 7-21	
A9R3		Same as A1R24				7-7, 7-21	
A9R4		Same as A1R24				7-7, 7-21	
A9R5		Same as A1R4				7-7, 7-21	
A9R6		Same as A1R4				7-7, 7-21	
A9R7		Same as A1R23				7-7, 7-21	
A9R8		Same as A1R23				7-7, 7-21	
A9R9		Same as A1R4				7-7, 7-21	
A9R10		Same as A2R11				7-7, 7-21	
A9R11		Same as A1R4				7-7, 7-21	
A9R12		Same as A1R23				7-7, 7-21	
A9R13		Same as A1R4				7-7, 7-21	
A9R14		Same as A1R23				7-7, 7-21	
A9R15		Same as A1R23				7-7, 7-21	
A9R16		Same as A3R10				7-7, 7-21	
A9R17		Same as A1R4				7-7, 7-21	
A9R18		Same as A2R9				7-7, 7-21	
A9R19		Same as A2R11				7-7, 7-21	
A9R20		Same as A2R9				7-7, 7-21	
A9R21		Same as A1R23				7-7, 7-21	
A9R22		Same as A2R11				7-7, 7-21	
A9R23		Same as A1R1				7-7, 7-21	
A9R24		RESISTOR, FIXED, COMPOSI- TION: 56K ohms, 10% 1/4W	X18453-562	81349	RC07GF563K	7-7, 7-21	2
A9R25		RESISTOR, FIXED, COMPOSI- TION: 5.6K ohms, 10%, 1/4W	X18452-562	81349	RC07GF562K	7-7, 7-21	1

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A9R26 A9R27		Same as A1R5 RESISTOR, FIXED, COMPOSITION: 560K ohms, 10%, 1/4W	X18454-562	81349	RC07GF564K	7-7, 7-21 7-7, 7-21	1
A9R28		RESISTOR, FIXED, COMPOSITION: 100K ohms, 10%, 1/4W	X18454-102	81349	RC07GF104K	7-7, 7-21	1
A9R29		Same as A9R24				7-7, 7-21	
A9R30		Same as A1R6				7-7, 7-21	
A9R31		Same as A1R6				7-7, 7-21	
A10	a	MODULE ASSEMBLY: integrator/differentiator	13630-911	28569		7-8, 7-22	1
A10C1	b	CAPACITOR, FIXED, MYLAR: 0.022 uf, 10%, 80V	3090-87	56289	192P2239R8	7-8, 7-22	1
A10C2		CAPACITOR, FIXED, MYLAR: 0.22 uf, 10%, 200V	3090-83	56289	192P22492	7-8, 7-22	1
A10C3		CAPACITOR, FIXED, ELECTROLYTIC: 1 uf, 15V	3085-388	01002	76F02FC1R0	7-8, 7-22	1
A10C4		CAPACITOR, FIXED, MYLAR: 2 uf, 5%, 200V	3090-85	09134	31-205C	7-8, 7-22	2
A10C5		CAPACITOR, FIXED, METALLIZED MYLAR: 0.047 uf, 5%, 50V	3090-86	59875	X663FR	7-8, 7-22	1
A10C6		Same as A10C4				7-8, 7-22	
A10CR1		Same as A1CR1				7-8, 7-22	
A10CR2		Same as A1CR1				7-8, 7-22	
A10CR3		Same as A1CR1				7-8, 7-22	
A10IC1		INTEGRATED CIRCUIT: operational amplifier	9800-50	07263	U6E7741393 (UA741C)	7-8, 7-22	2
A10IC2		Same as A10IC1				7-8, 7-22	
A10Q1		Same as A1Q1				7-8, 7-22	
A10Q2		Same as A1Q1				7-8, 7-22	
A10Q3		TRANSISTOR: 2N5457	20861-167	04713	MPF103 (2N2457)	7-8, 7-22	1
A10R1		RESISTOR, FIXED, COMPOSITION: 2.2K ohms, 5%, 1/4W	X18452-221	81349	RC07GF222J	7-8, 7-22	4
A10R2		Same as A10R1				7-8, 7-22	
A10R3		Same as A10R1				7-8, 7-22	
A10R4		Same as A10R1				7-8, 7-22	
A10R5		RESISTOR, FIXED, COMPOSITION: 68K ohms, 5%, 1/4W	X18453-681	81349	RC07GF683J	7-8, 7-22	1
A10R6		RESISTOR, FIXED, COMPOSITION: 1K ohms, 5%, 1/4W	X18452-101	81349	RC07GF102J	7-8, 7-22	4
A10R7		RESISTOR, FIXED, COMPOSITION: 390K ohms, 5%, 1/4W	X18454-391	81349	RC07GF394J	7-8, 7-22	1
A10R8	c	RESISTOR, FIXED, FILM: 63.4K ohms, 1%, 1/4W	18554-70	81349	RN60D6342F	7-8, 7-22	1
A10R9		RESISTOR, VARIABLE: wire wound, 20K ohms, 10%, 1/2W	16925-695	80294	3067P-1-203	7-8, 7-22	1
A10R10		RESISTOR, FIXED, COMPOSITION: 2.7K ohms, 5%, 1/4W	X18452-271	81349	RC07GF272J	7-8, 7-22	1
A10R11		Same as A10R6				7-8, 7-22	
A10R12		RESISTOR, FIXED, COMPOSITION: 1 megohm, 5%, 1/4W	X18455-101	81349	RC07GF105J	7-8, 7-22	1
A10R13		RESISTOR, FIXED, COMPOSITION: 6.8K ohms, 5%, 1/4W	X18452-681	81349	RC07GF682J	7-8, 7-22	1

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A10R14		RESISTOR, VARIABLE: wire wound, 2K ohms, 10%, 1/2W	16925-694	80294	3067P-1-202	7-8, 7-22	1
A10R15		RESISTOR, FIXED, FILM: 9090 ohms, 1%, 1/4W	18554-71	81349	RN60D9091F	7-8, 7-22	1
A10R16		RESISTOR, FIXED, FILM: 14K ohms, 1%, 1/4W	18554-66	81349	RN60D1402F	7-8, 7-22	1
A10R17		RESISTOR, FIXED, COMPOSITION: 1.8K ohms, 5%, 1/4W	18452-181	81349	RC07GF182J	7-8, 7-22	1
A11	a	MODULE ASSEMBLY: scope driver	13630-909	28569		7-9, 7-23	1
A11C1		Same as A8C4				7-9, 7-23	
A11C2		CAPACITOR, FIXED, MYLAR: 0.0022 uf, 10%, 200V	3090-84	56289	192P22292	7-9, 7-23	2
A11C3		Same as A1C3				7-9, 7-23	
A11C4		Same as A5C3				7-9, 7-23	
A11C5		Same as A8C4				7-9, 7-23	
A11C6		Same as A1C3				7-9, 7-23	
A11C7		Same as A5C3				7-9, 7-23	
A11C8		Same as A1C3				7-9, 7-23	
A11C9		Same as A11C2				7-9, 7-23	
A11CR1		Same as A1CR1				7-9, 7-23	
A11CR2		Same as A1CR1				7-9, 7-23	
A11Q1		Same as A8Q2				7-9, 7-23	
A11Q2		Same as A1Q10				7-9, 7-23	
A11Q3		Same as A1Q10				7-9, 7-23	
A11Q4		Same as A1Q1				7-9, 7-23	
A11Q5		Same as A1Q10				7-9, 7-23	
A11Q6		TRANSISTOR: 2N708	20861-256	04713	2N708	7-9, 7-23	1
A11Q7		Same as A1Q10				7-9, 7-23	
A11Q8		Same as A1Q1				7-9, 7-23	
A11Q9		Same as A8Q2				7-9, 7-23	
A11Q10		Same as A1Q10				7-9, 7-23	
A11Q11		Same as A1Q10				7-9, 7-23	
A11R1		RESISTOR, FIXED, COMPOSITION: 1 megohm, 10%, 1/4W	X18455-102	81349	RC07GF105K	7-9, 7-23	4
A11R2		Same as A11R1				7-9, 7-23	
A11R3		RESISTOR, FIXED, FILM: 100K ohms, 1%, 1/8W	18554-45	81349	RN55D1003F	7-9, 7-23	4
A11R4		Same as A11R3				7-9, 7-23	
A11R5		RESISTOR, FIXED, COMPOSITION: 10 megohms, 10%, 1/4W	X18456-102	81349	RC07GF106K	7-9, 7-23	2
A11R6		RESISTOR, FIXED, FILM: 21.5K ohms, 1%, 1/8W	18554-50	81349	RN55D2152F	7-9, 7-23	2
A11R7		RESISTOR, VARIABLE: wire wound, 10K ohms	16925-693	73138	62PR10K	7-9, 7-23	2
A11R8		Same as A1R2				7-9, 7-23	
A11R9		RESISTOR, FIXED, FILM: 11K ohms, 1%, 1/8W	18554-46	81349	RN55D1102F	7-9, 7-23	2
A11R10		RESISTOR, FIXED, FILM: 5.11K ohms, 1%, 1/8W	18554-58	81349	RN55D5111F	7-9, 7-23	2
A11R11		RESISTOR, VARIABLE: wire wound, 5K ohms	16925-685	73138	62PR5K	7-9, 7-23	1
A11R12		RESISTOR, FIXED, FILM: 12.1K ohms, 1%, 1/8W	18554-48	81349	RN55D1212F	7-9, 7-23	1
A11R13		RESISTOR, FIXED, FILM: 7.5K ohms, 1%, 1/8W	18554-62	81349	RN55D7501F	7-9, 7-23	1

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A11R14		RESISTOR, FIXED, FILM: 750 ohms, 1%, 1/8W	18554-61	81349	RN55D7500F	7-9, 7-23	1
A11R15		Same as A1R5				7-9, 7-23	
A11R16		RESISTOR, FIXED, COMPOSI- TION: 1.8K ohms, 10%, 1/4W	X18452-182	81349	RC07GF182K	7-9, 7-23	2
A11R17		Same as A2R11				7-9, 7-23	
A11R18		Same as A1R2				7-9, 7-23	
A11R19		Same as A2R11				7-9, 7-23	
A11R20		Same as A2R6				7-9, 7-23	
A11R21		RESISTOR, VARIABLE: wire wound, 1K ohms, 10%, 1/2W	16925-690	80294	3067P-1-102	7-9, 7-23	1
A11R22		RESISTOR, VARIABLE: wire wound, 5K ohms, 10%, 1/2W	16925-691	80294	3067P-1-502	7-9, 7-23	1
A11R23		Same as A11R10				7-9, 7-23	
A11R24		Same as A11R16				7-9, 7-23	
A11R25		RESISTOR, FIXED, FILM: 5.23K ohms, 1%, 1/8W	18554-59	81349	RN55D5231F	7-9, 7-23	1
A11R26		RESISTOR, FIXED, FILM: 9090 ohms, 1%, 1/8W	18554-63	81349	RN55D9091F	7-9, 7-23	1
A11R27		Same as A11R9				7-9, 7-23	
A11R28		Same as A11R3				7-9, 7-23	
A11R29		Same as A11R7				7-9, 7-23	
A11R30		Same as A11R3				7-9, 7-23	
A11R31		Same as A1R6				7-9, 7-23	
A11R32		Same as A1R2				7-9, 7-23	
A11R33		Same as A11R1				7-9, 7-23	
A11R34		Same as A11R1				7-9, 7-23	
A11R35		Same as A11R6				7-9, 7-23	
A11R36		Same as A11R5				7-9, 7-23	
A11R37		Same as A1R6				7-9, 7-23	
A12		BOARD ASSEMBLY: extender	2421-108	28569		7-2	1
A12J1		CONNECTOR: 15 pin	3475-281	71785	251-15-30-160	P/O A12	14
A13	a	MODULE ASSEMBLY: power supply regulator	13630-902	28569		7-10, 7-24	1
A13C1		NOT ASSIGNED				7-10, 7-24	
A13C2		NOT ASSIGNED				7-10, 7-24	
A13C3		NOT ASSIGNED				7-10, 7-24	
A13C4		NOT ASSIGNED				7-10, 7-24	
A13C5		Same as A9C6				7-10, 7-24	
A13C6		CAPACITOR, FIXED, ELEC- TROLYTIC: 100 uf, 25V	3085-267	01002	76F02KM101	7-10, 7-24	4
A13C7		Same as A9C6				7-10, 7-24	
A13C8		Same as A13C6				7-10, 7-24	
A13C9		Same as A9C6				7-10, 7-24	
A13C10		Same as A13C6				7-10, 7-24	
A13C11		Same as A9C6				7-10, 7-24	
A13C12		Same as A13C6				7-10, 7-24	
A13CR1		NOT ASSIGNED				7-10, 7-24	
A13CR2		NOT ASSIGNED				7-10, 7-24	
A13CR3		NOT ASSIGNED				7-10, 7-24	
A13CR4		NOT ASSIGNED				7-10, 7-24	
A13CR5		SEMICONDUCTOR DEVICE: zener diode 1N750A	3870-131	07910	1N750A	7-10, 7-24	2
A13CR6		Same as A13CR5				7-10, 7-24	
A13CR7		Same as A1CR1				7-10, 7-24	
A13CR8		Same as A1CR1				7-10, 7-24	

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A13CR9		Same as A1CR1				7-10, 7-24	
A13CR10		Same as A1CR1				7-10, 7-24	
A13CR11		Same as A1CR1				7-10, 7-24	
A13CR12		Same as A1CR1				7-10, 7-24	
A13CR13		Same as A1CR1				7-10, 7-24	
A13CR14		Same as A1CR1				7-10, 7-24	
A13CR15		Same as A1CR1				7-10, 7-24	
A13CR16		Same as A1CR1				7-10, 7-24	
A13CR17		Same as A1CR1				7-10, 7-24	
A13CR18		Same as A1CR1				7-10, 7-24	
A13CR19		SEMICONDUCTOR DEVICE: zener diode, selected	3870-242	28569		7-10, 7-24	1
A13Q1		NOT ASSIGNED				7-10, 7-24	
A13Q2		NOT ASSIGNED				7-10, 7-24	
A13Q3		NOT ASSIGNED				7-10, 7-24	
A13Q4		NOT ASSIGNED				7-10, 7-24	
A13Q5		TRANSISTOR: 2N3053	20861-75	86684	2N3053	7-10, 7-24	3
A13Q6		Same as A1Q10				7-10, 7-24	
A13Q7		Same as A1Q10				7-10, 7-24	
A13Q8		TRANSISTOR: 2N3644	20861-107	07263	2N3644	7-10, 7-24	3
A13Q9		Same as A13Q8				7-10, 7-24	
A13Q10		Same as A13Q8				7-10, 7-24	
A13Q11		Same as A13Q5				7-10, 7-24	
A13Q12		Same as A1Q10				7-10, 7-24	
A13Q13		Same as A1Q10				7-10, 7-24	
A13Q14		Same as A13Q5				7-10, 7-24	
A13Q15		Same as A1Q10				7-10, 7-24	
A13Q16		Same as A1Q10				7-10, 7-24	
A13R1		NOT ASSIGNED				7-10, 7-24	
A13R2		NOT ASSIGNED				7-10, 7-24	
A13R3		NOT ASSIGNED				7-10, 7-24	
A13R4		NOT ASSIGNED				7-10, 7-24	
A13R5		NOT ASSIGNED				7-10, 7-24	
A13R6		NOT ASSIGNED				7-10, 7-24	
A13R7		NOT ASSIGNED				7-10, 7-24	
A13R8		NOT ASSIGNED				7-10, 7-24	
A13R9		RESISTOR, FIXED, COMPOSI- TION: 620 ohms, 10%, 1/2W	X18411-622	81349	RC20GF621K	7-10, 7-24	1
A13R10		RESISTOR, FIXED, COMPOSI- TION: 8.2K ohms, 10%, 1/4W	X18452-822	81349	RC07GF822K	7-10, 7-24	2
A13R11		Same as A1R27				7-10, 7-24	
A13R12		RESISTOR, FIXED, COMPOSI- TION: 330 ohms, 10%, 1/4W	X18451-332	81349	RC07GF331K	7-10, 7-24	5
A13R13		RESISTOR, FIXED, FILM: 1.1K ohms, 1%, 1/4W	18554-67	81349	RN60D1101F	7-10, 7-24	1
A13R14		Same as A1R23				7-10, 7-24	
A13R15		RESISTOR, FIXED, FILM: 499 ohms, 1%, 1/4W	18554-68	81349	RN60D4990F	7-10, 7-24	1
A13R16		Same as A1R23				7-10, 7-24	
A13R17		RESISTOR, FIXED, COMPOSI- TION: 510 ohms, 5%, 1/4W	X18451-511	81349	RC07GF511J	7-10, 7-24	2
A13R18		Same as A13R10				7-10, 7-24	
A13R19		Same as A2R11				7-10, 7-24	
A13R20		Same as A1R27				7-10, 7-24	
A13R21		Same as A13R12				7-10, 7-24	
A13R22		RESISTOR, FIXED, COMPOSI- TION: 1.1K ohms, 5%, 1/4W	X18452-111	81349	RC07GF112J	7-10, 7-24	1

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
A13R23 A13R24 A13R25		Same as A1R27 Same as A13R12 RESISTOR, FIXED, COMPOSITION: 1.5K ohms, 5%, 1/4W	X18452-151	81349	RC07GF152J	7-10, 7-24 7-10, 7-24 7-10, 7-24	1
A13R26 A13R27		Same as A10R6 RESISTOR, FIXED, COMPOSITION: 3.0K ohms, 5%, 1/4W	X18452-301	81349	RC07GF302J	7-10, 7-24 7-10, 7-24	1
A13R28 A13R29 A13R30 A13R31		Same as A13R12 Same as A13R12 Same as A1R27 RESISTOR, FIXED, COMPOSITION: 270 ohms, 10%, 1/4W	X18451-272	81349	RC07GF271K	7-10, 7-24 7-10, 7-24 7-10, 7-24 7-10, 7-24	1
A13R32 A13R33 A13R34 A13R35		Same as A1R4 Same as A13R17 Same as A10R6 RESISTOR, FIXED, COMPOSITION: 4.3K ohms, 5%, 1/4W	X18452-431	81349	RC07GF432J	7-10, 7-24 7-10, 7-24 7-10, 7-24 7-10, 7-24	1
A14		BOARD ASSEMBLY: power supply rectifier	2421-97	28569		7-11, 7-25	1
A14C1		CAPACITOR, FIXED, ELECTROLYTIC: 4 uf, 450V	3085-385	56289	TVA-1702	7-11, 7-25	1
A14C2		CAPACITOR, FIXED, ELECTROLYTIC: 2000 uf, 30V	3085-389	56289	601D208G030 HS4	7-11, 7-25	1
A14C3		CAPACITOR, FIXED, ELECTROLYTIC: 1000 uf, 30V	3085-390	56289	601D108G030 FT4	7-11, 7-25	1
A14C4		CAPACITOR, FIXED, ELECTROLYTIC: 5700 uf, 15V	3085-391	56289	601D578G015 JS4	7-11, 7-25	1
A14CR1		SEMICONDUCTOR DEVICE: diode 1N3255	3870-270	86684	1N3255	7-11, 7-25	1
A14CR2		SEMICONDUCTOR DEVICE: rectifier, diode bridge	18150-81	53562	VE18	7-11, 7-25	1
A14CR3		SEMICONDUCTOR DEVICE: diode 1N2069	3870-62	01295	1N2069	7-11, 7-25	2
A14CR4 A14R1		Same as A14CR3 RESISTOR, FIXED, COMPOSITION: 20K ohms, 10%, 1/2W	X18413-202	81349	RC20GF203K	7-11, 7-25 7-11, 7-25	1
A14R2		RESISTOR, FIXED, COMPOSITION: 1 ohm, 10%, 1/2W	X18525-815	81349	RC20GF010K	7-11, 7-25	5
A14R3 A14R4 A14R5 A14R6 A14R7		Same as A14R2 Same as A14R2 Same as A14R2 Same as A14R2 RESISTOR, FIXED, COMPOSITION: 47K ohms, 10%, 1/2W	X18413-472	81349	RC20GF473K	7-11, 7-25 7-11, 7-25 7-11, 7-25 7-11, 7-25 7-11, 7-25	1
A14R8		RESISTOR, FIXED, COMPOSITION: 1 megohm, 10%, 1/2W	X18415-102	81349	RC20GF105K	7-11, 7-25	1
A15		BRACKET ASSEMBLY: transistor heatsink	2661-369	28569		7-26	1
A15Q1		TRANSISTOR: MJE520	20861-129	04713	MJE520	7-26	3
A15Q2		TRANSISTOR: MJE370	20861-128	04713	MJE370	7-26	1
A15Q3		Same as A15Q1				7-26	
A15Q4		Same as A15Q1				7-26	
C1		Same as A1C2				7-13	

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
C2		Same as A1C2				7-13	
C3		CAPACITOR, FIXED ELECT: 330 uf $\pm 20\%$, 6 volts	3085-296	01002	76F02CN331	7-1	2
C4		Same as C3				7-1	
DS1		LAMP: neon	12270-51	08806	NE-2D	7-12	1
DS2		LAMP: 28 volt, single contact, midget flanged	12270-38	08806	327	7-12	1
E1		BINDING POST: black	2360-106	74970	111-103	7-14	1
E2		BINDING POST: red	2360-107	74970	111-102	7-14	1
F1		FUSE: 0.5 amp, 250 volts	6900-75	71400	AGC1/2	7-13	1
J1		CONNECTOR: BNC, UG-657/U	3475-144	02660	31-102	7-12	8
J2		Same as J1				7-12	
J3		Same as J1				7-14	
J4		Same as J1				7-14	
J5		CONNECTOR: 7 pin	3475-202	02660	126-198	7-14	1
J6		Same as J1				7-12	
J7		Same as J1				7-12	
J8		Same as J1				7-12	
J9		Same as J1				7-12	
M1		METER: 0 center, 100-0-100 ua dc $\pm 1\%$ at all cardinal points	340-016	28569		7-12	1
P1		PLUG: p/b W1				7-1	
R1		RESISTOR, FIXED, COMPOSI- TION: 1.5K ohms, 10%, 1/4W	X18452-152	81349	RC07GF152K	7-13	5
R2		Same as R1				7-13	
R3		Same as R1				7-13	
R4		Same as R1				7-13	
R5		Same as R1				7-13	
R6		Same as A1R23				7-13	
R7		Same as A1R23				7-13	
R8		RESISTOR, VARIABLE: com- position, 25K ohms, 10%, 2W	40600-253	81349	RV4NAYSD253A	7-12	1
R9		RESISTOR, VARIABLE: com- position, 100K ohms, 10%, 2W	40600-104	81349	RV4NAYSD104A	7-12	2
R10		Same as R9				7-12	
R11		RESISTOR, VARIABLE: com- position, 10K ohms, 10%, 2W	40100-103	01121	JU1031503056	7-12	1
R12		RESISTOR, VARIABLE: com- position, 5K ohms, 10%, 2W	40700-502	81349	RV4LAYSA502A	7-14	1
S1		SWITCH: toggle, dpst	19911-115	72653	34-182	7-12	2
S2		SWITCH: slide	19911-117	82389	46256LF	7-14	1
S3		SWITCH: rotary	19912-656	28569		7-12	1
S4		SWITCH: toggle, dpdt	19911-116	72653	34-192	7-12	1
S5		Same as S1				7-12	
T1		TRANSFORMER ASSEMBLY: power	20800-385	28569		7-1, 7-13	1
T2		TRANSFORMER: isolation, 5 mh, 1:1	20800-378	01961	4294	7-13	2
T3		Same as T2				7-13	
V1		TUBE: cathode ray, type 1EP1	20875-278	86684	1EP1	7-12	1
W1		CABLE ASSEMBLY: power	3675-34	28569		3-2, 7-1	1
XA1		Same as A12J1				7-13	
XA2		Same as A12J1				7-13	
XA3		Same as A12J1				7-13	
XA4		Same as A12J1				7-13	
XA5		Same as A12J1				7-13	

Ref. Desig.	Notes	Name and Description	Hickok Part No.	Mfrs Code	Manufacturers Part No.	Fig. No.	Quant Per Equip.
XA6		Same as A12J1				7-13	
XA7		Same as A12J1				7-13	
XA8		Same as A12J1				7-13	
XA9		Same as A12J1				7-13	
XA10		Same as A12J1				7-13	
XA11		Same as A12J1				7-13	
XA12		Same as A12J1				7-13	
XA13		Same as A12J1				7-13	
XDS1		LAMPHOLDER: red lens	19350-493	72765	5133-048-703	7-12	1
XDS2		LAMPHOLDER: amber lens	19350-492	72765	5131-038-303	7-12	1
XF1		FUSEHOLDER	8825-14	71400	HKP	7-13	1
XV1		SOCKET: 11 pin for cathode ray tube type 1EP1	19350-491	01009	411SBU	7-12	1

Table 6-2. List of Manufacturers

Code	Name and Address	Code	Name and Address
01002	General Electric Co. Capacitor Dept. John St. Hudson Falls, N.Y. 12839	07910	Continental Device Corp. 12515 Chardon Hawthorne, Calif. 90250
01009	Alden Products Co. 117 N. Main St. Brockton, Mass. 02403	08806	General Electric Miniature Lamp Dept. Nela Park Cleveland, Ohio 44112
01121	Allen Bradley Co. 1201 S. 2nd St. Milwaukee, Wis. 53204	09134	Texas Capacitor Co. 7830 Westglen Dr. P.O. Box 36275 Houston, Texas, 77042
01295	Texas Instruments, Inc. 13500 N. Central Expressway Box 5474 Dallas, Texas 75231	28569	Hickok Electrical Instrument Co. 10514 Dupont Ave. Cleveland, Ohio 44108
01961	Pulse Engineering, Inc. 560 Robert Ave. Santa Clara, Calif. 95050	31433	Union Carbide Corp. Electronics Div. Highway 276, S.E. Greenville, S.C. 29606
02660	Amphenol Corp. 2801 S. 25th St. Broadview, Ill. 60153	53021	Sangamo Electric Co. 1301 N. 11th St. Springfield, Ill. 62705
04713	Motorola Semiconductor Products., Inc. 5005 E. McDowell Rd. Phoenix, Ariz. 85008	53562	Varo Special Products Div. 2203 Walnut St. Garland, Texas 75040
07263	Fairchild Camera and Instrument Corp. Semiconductor Division 313 Frontage Rd. Mountain View, Calif. 94041	56289	Sprague Electric Co. 481 Marshall St. North Adams, Mass. 01247

Code	Name and Address	Code	Name and Address
59875	TRW, Inc. Accessories Div. 23555 Euclid Ave. Cleveland, Ohio 44117	73899	JFD Electronics 15th Ave. at 62nd St. Brooklyn, N. Y. 12839
71400	Bussman Manufacturing 2536 W. University St. Louis, Mo. 63017	74970	E. F. Johnson Co. 297 Tenth Ave., S.W. Waseca, Minn. 56093
71590	Centralab Div. of Globe Union, Inc. 900A E. Keefe Ave. Milwaukee, Wis. 53201	80294	Bourns Laboratories, Inc. 1200 Columbia Ave. Riverside, Calif. 92507
71785	Cinch-Jones Mfg. Co. 1026 S. Homan Ave. Chicago, Ill. 60624	81349	Military Specifications promulgated by Standardization Division Directorate of Logistic Services, DSA
72653	G. C. Electronics Co. 400 S. Wyman St. Rockford, Ill. 61101	82389	Switchcraft, Inc. 5527 N. Elston Ave. Chicago, Ill. 60630
72765	Drake Mfg. Co. 4626 Olcott Ave. Hardwood Hts., Ill. 60656	84171	Arco Electronics Community Drive Great Neck, N. Y. 11022
72982	Erie Technological Products, Inc. 644 W. 12th St. Erie, Pa. 16512	86684	RCA Electronic Components and Devices 415 S. 5th St. Harrison, N.J. 07029
73138	Beckman Instruments, Inc. Helipot Div. 2500 Harbor Blvd. Fullerton, Calif. 92634	91506	Augat, Inc. 33 Perry Ave. Attleboro, Mass. 02703
73445	Amperex Electronic Corp. 230 Duffy Ave. Hicksville, Long Island, N. Y. 11800	93790	Cornell-Dubilier Electronics Division Federal Pacific Electric Corp. 1605 Rodney French Blvd. New Bedford, Mass. 02741

SECTION VII

ILLUSTRATIONS

SCHEMATIC DIAGRAMS,
PARTS LOCATION DIAGRAMS
AND PHOTOGRAPHS

IMPORTANT

For complete reference designations of parts shown on figures 7-2 through 7-11 and 7-15 through 7-26, add the prefix specified under "NOTES" on the illustration to the basic part designations as shown on that illustration.

Example: The complete reference designation for R1 on figure 7-2 is A1R1.

It is essential that the complete reference designation be used when locating an item in the Parts List, Section VI.

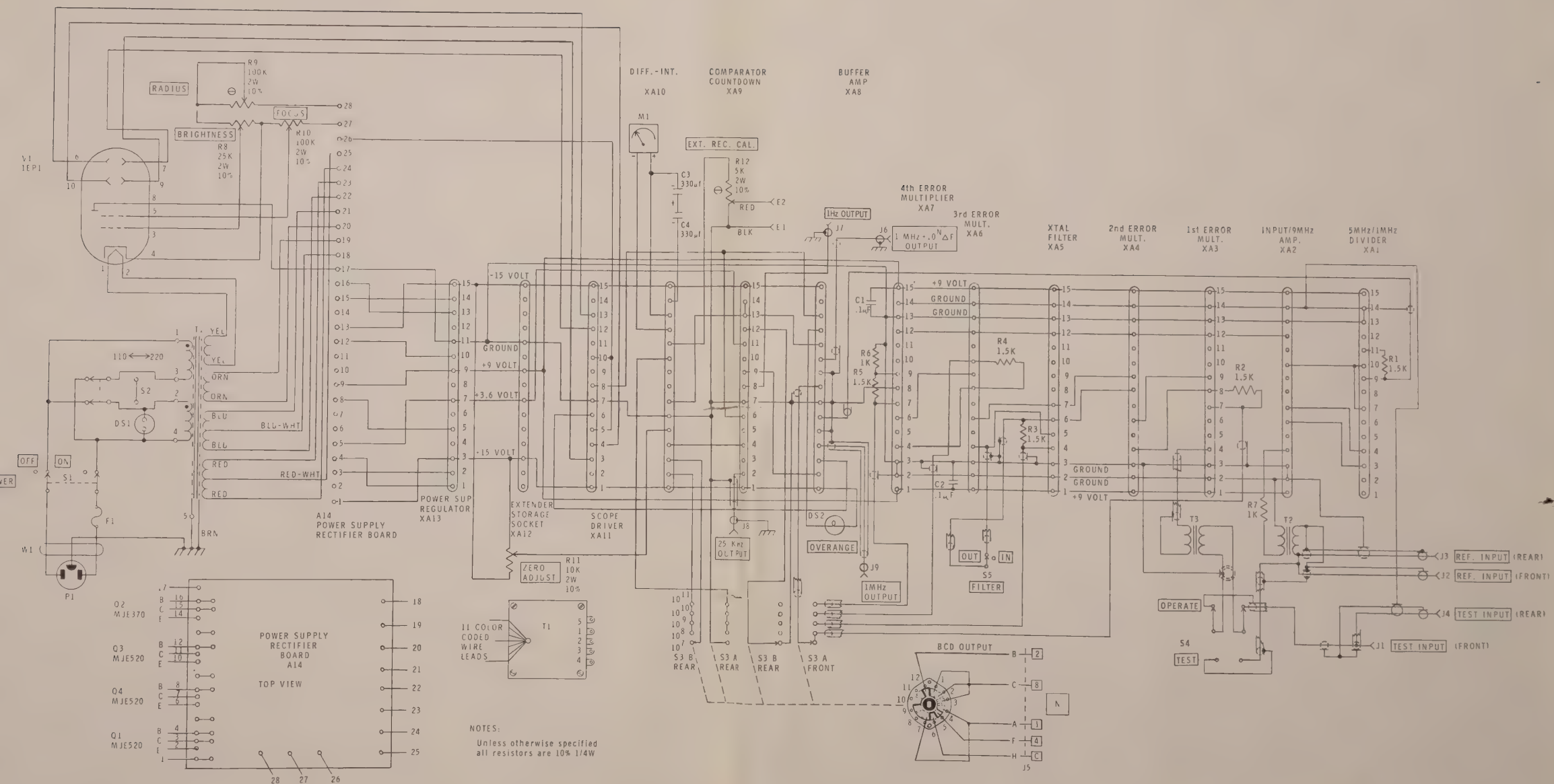
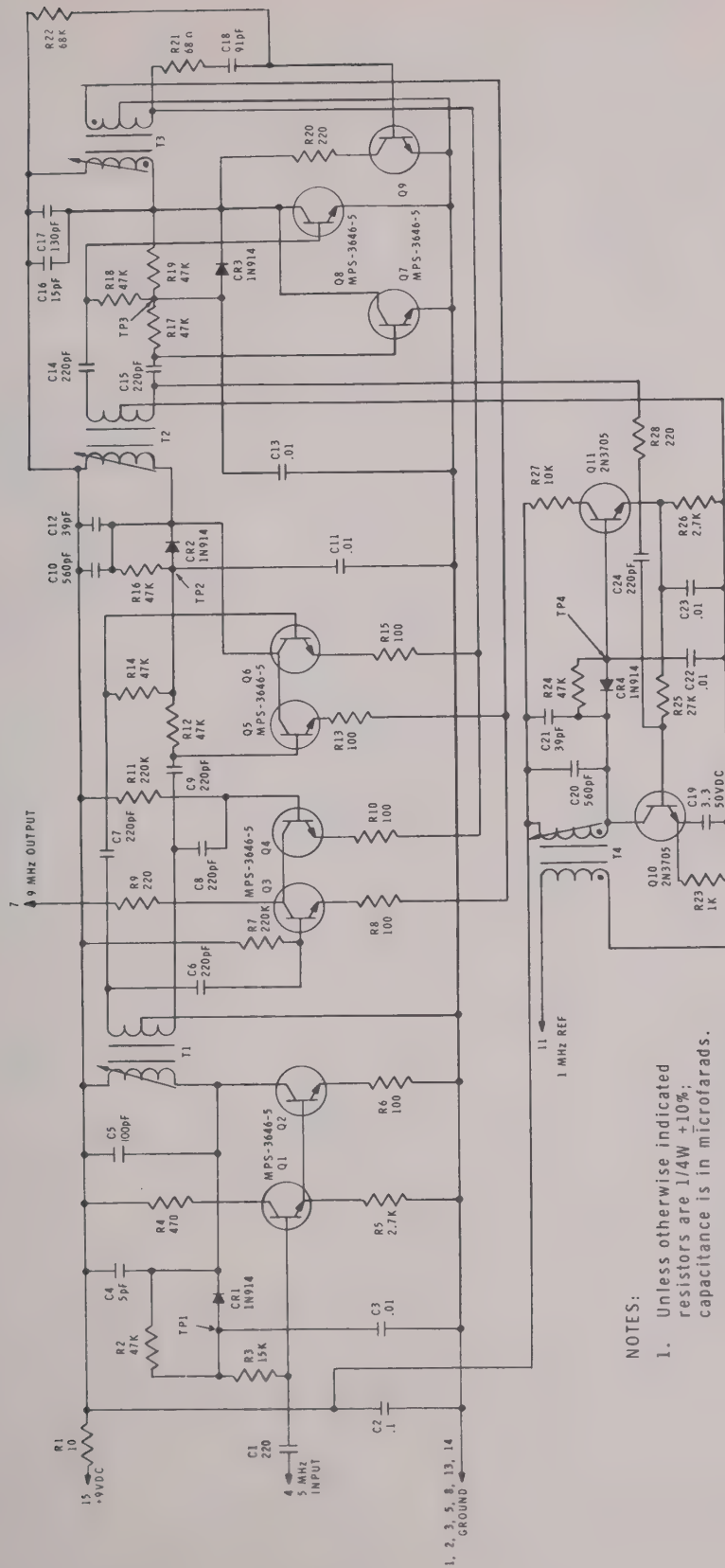


Figure 7-1. Schematic Diagram, Main Chassis Assembly



NOTES:

1. Unless otherwise indicated resistors are 1/4W $\pm 10\%$; capacitance is in microfarads.
2. For complete reference designation add the prefix A1 to the basic part designations shown on this illustration.

Figure 7-2. Schematic Diagram, 5 MHz/1 MHz Divider (Assembly A1)

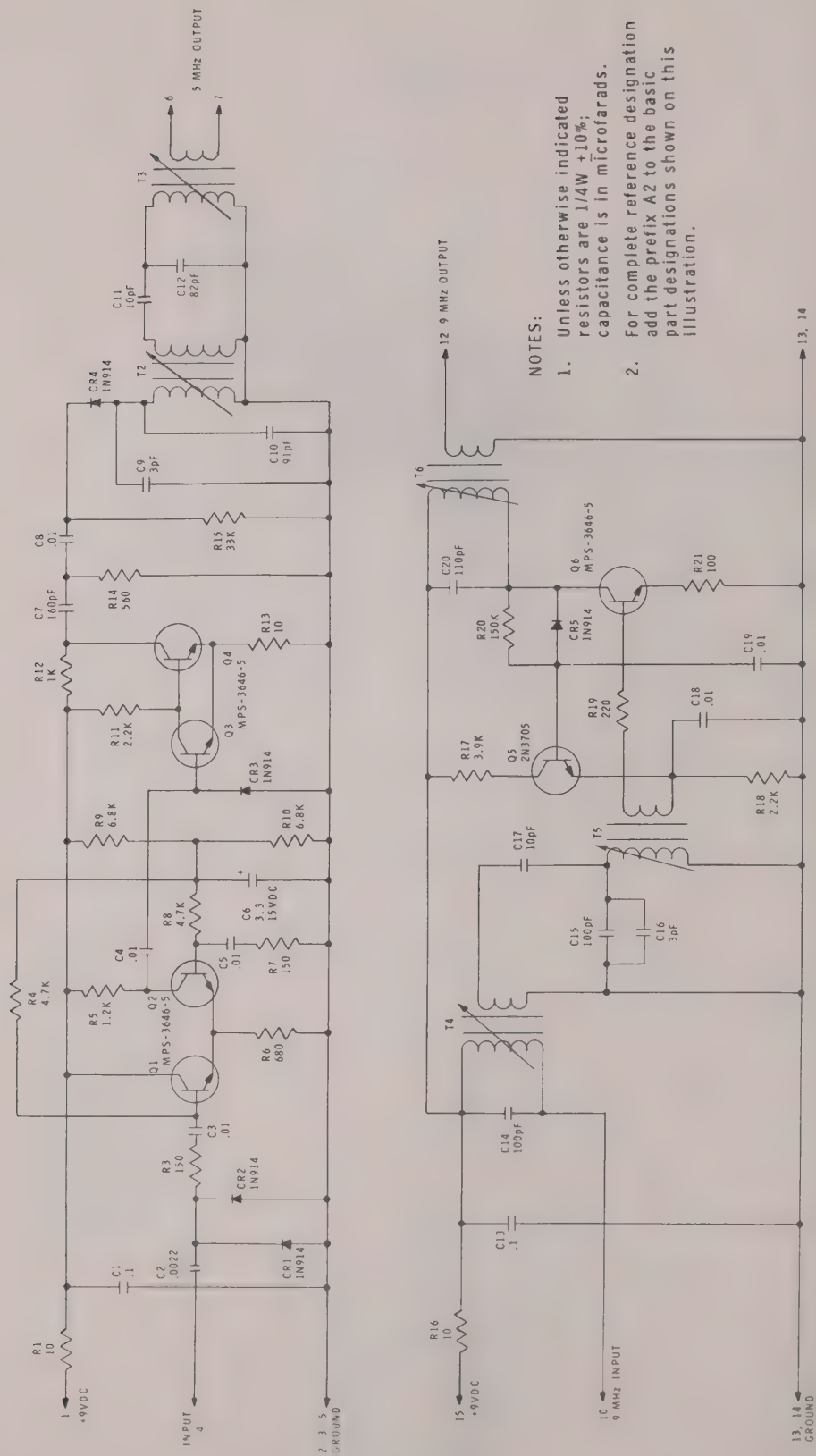
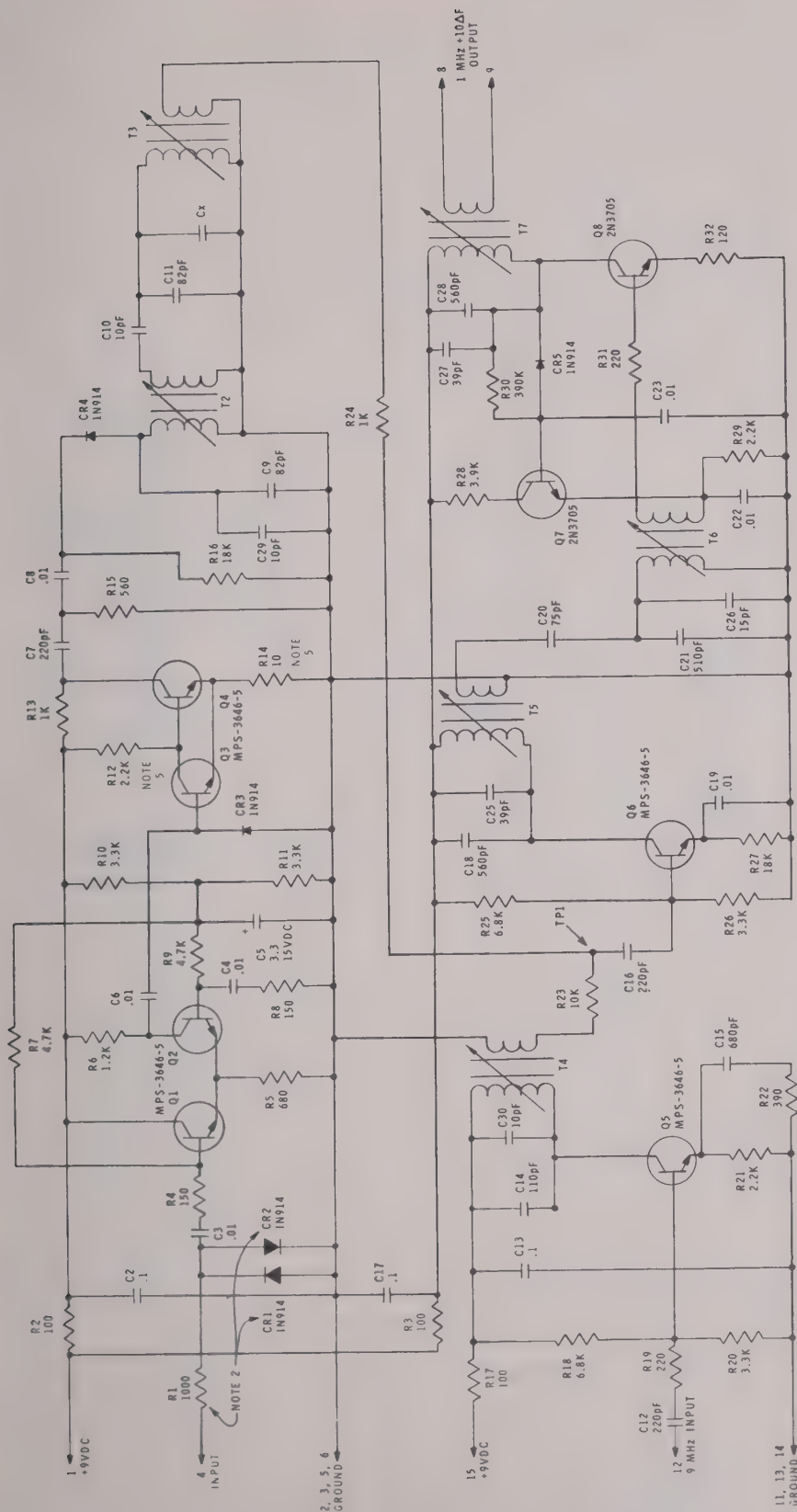


Figure 7-3. Schematic Diagram, Input/9 MHz Amplifier (Assembly A2)



NOTES:

1. Unless otherwise indicated resistors are 1/4W ±10%; capacitance is in microfarads.
2. All error multipliers are identical except R1, CR1, and CR2 do not appear on the 2nd, 3rd, and 4th error multipliers.
3. Cx indicates calibration capacitor, exact value determined during calibration if required.
4. For complete reference designation, add to the basic part designations shown on this illustration, a prefix selected from the chart shown below:

A3 - 1st error multiplier
A4 - 2nd error multiplier
A6 - 3rd error multiplier
A7 - 4th error multiplier
5. On 2nd, 3rd, and 4th error multipliers R12-10K and R14=100Ω.

Figure 7-4. Schematic Diagram, Error Multipliers Assemblies A3, A4, A6 and A7)

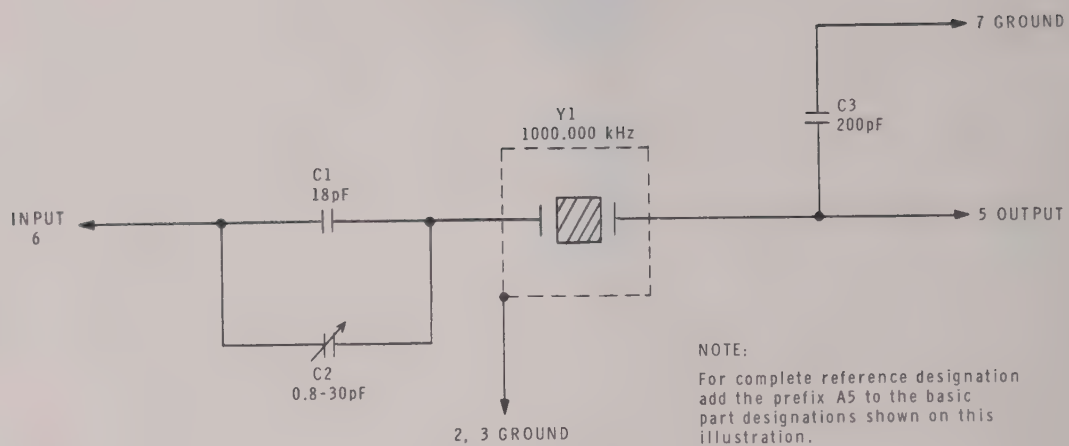


Figure 7-5. Schematic Diagram, Crystal Filter (Assembly A5)

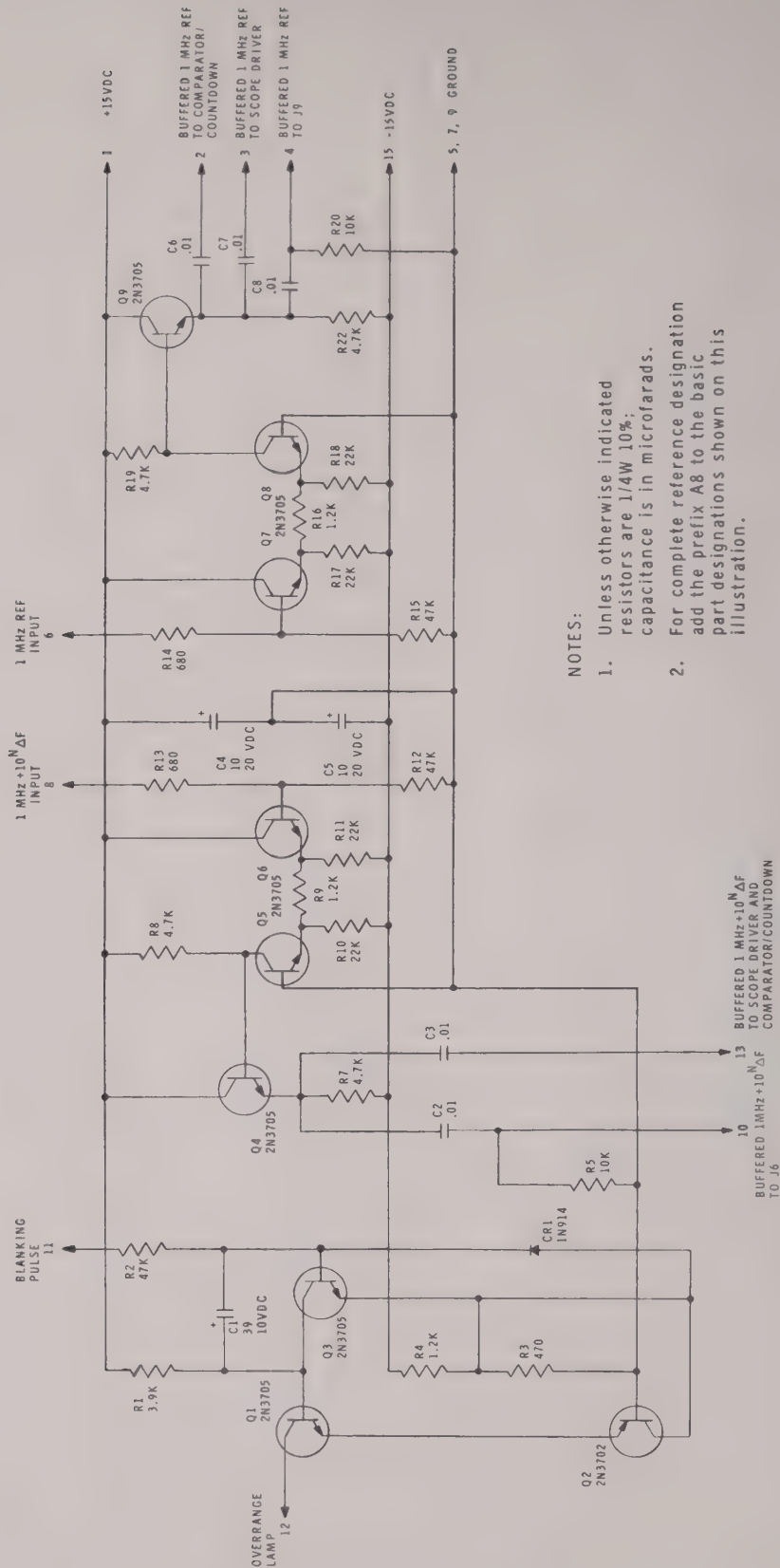


Figure 7-6. Schematic Diagram, Buffer Amplifier (Assembly A8)

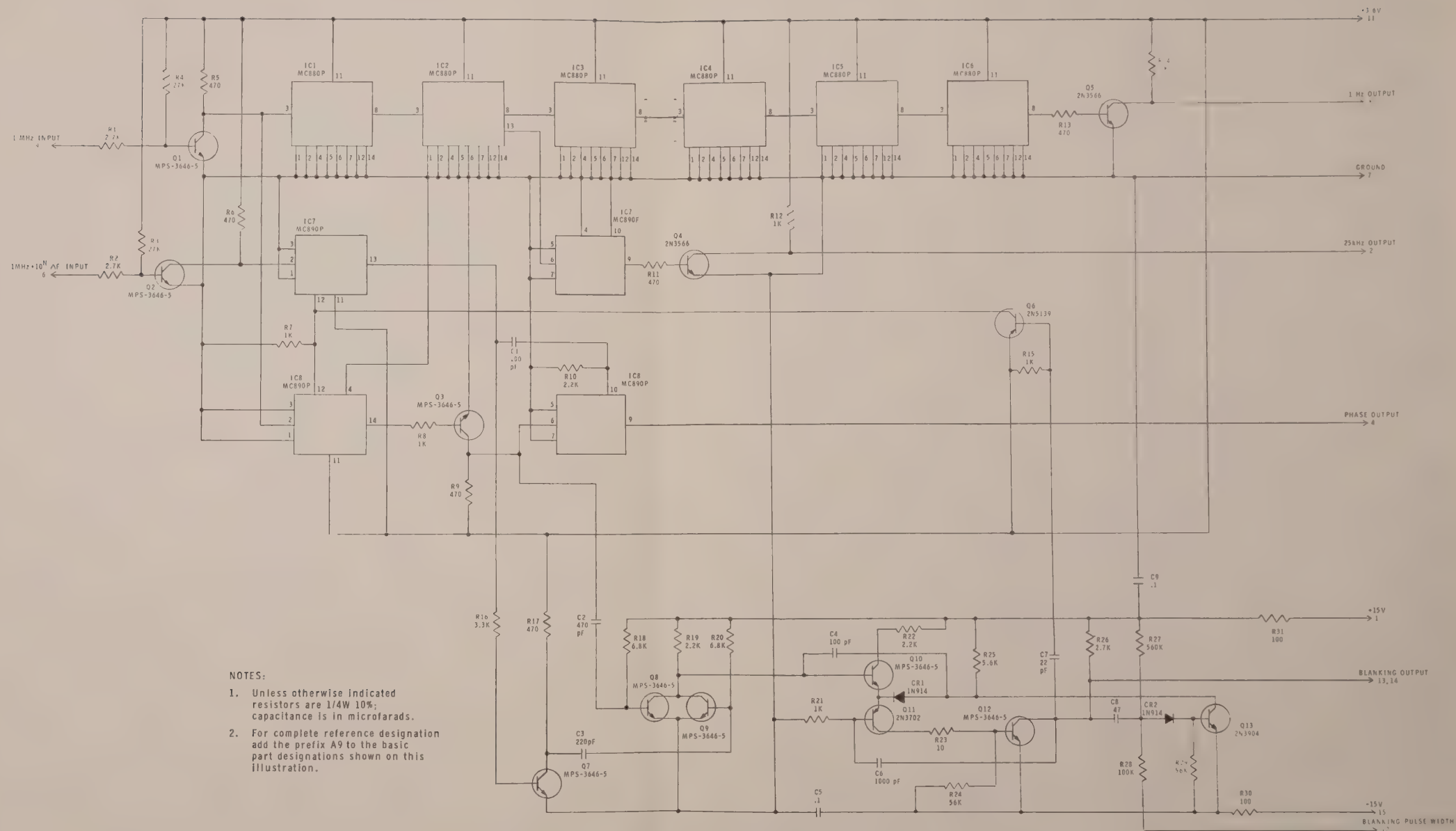


Figure 7-7. Schematic Diagram, Comparator Countdown (Assembly A9)

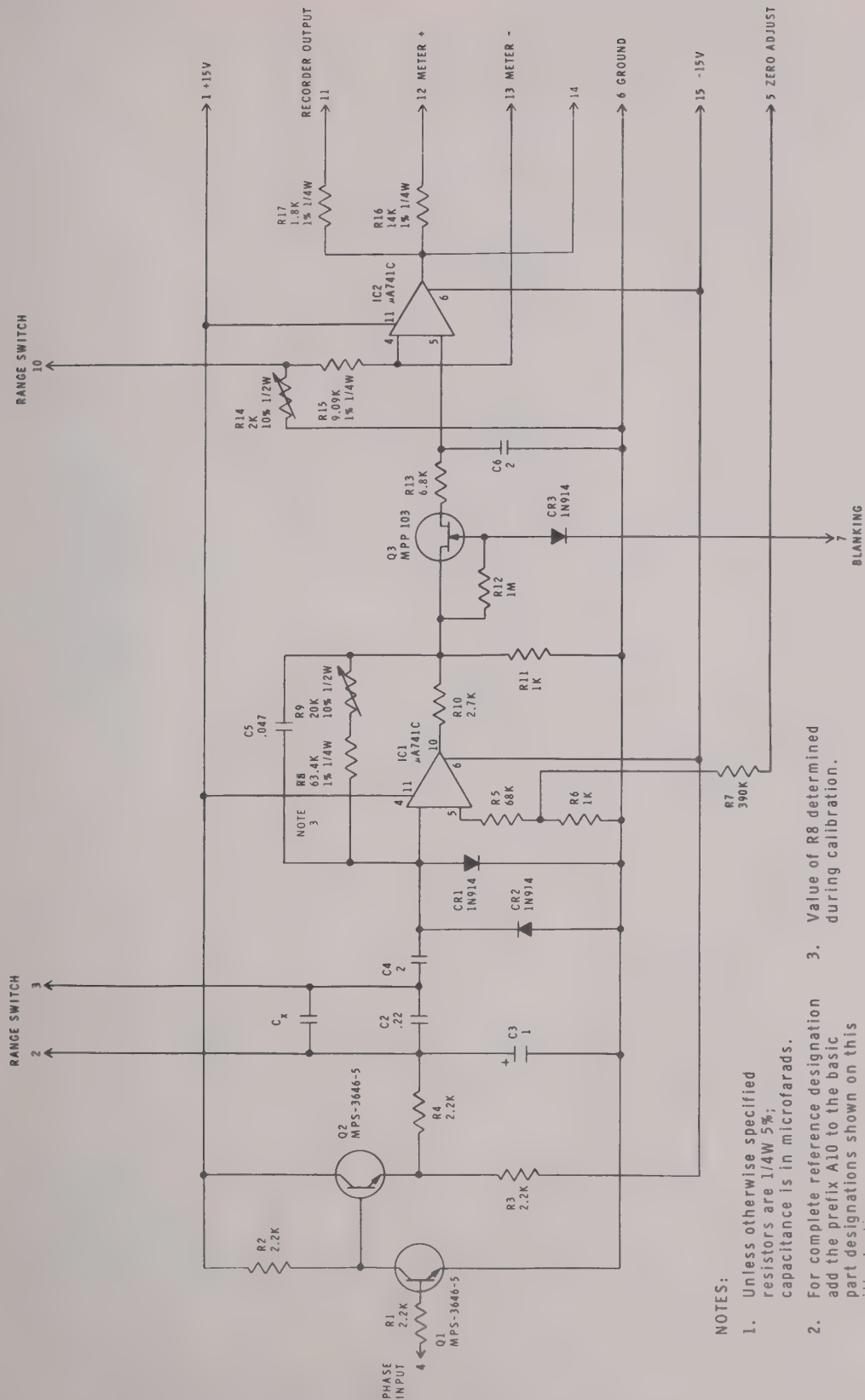


Figure 7-8. Schematic Diagram, Integrator-Differentiator (Assembly A10)

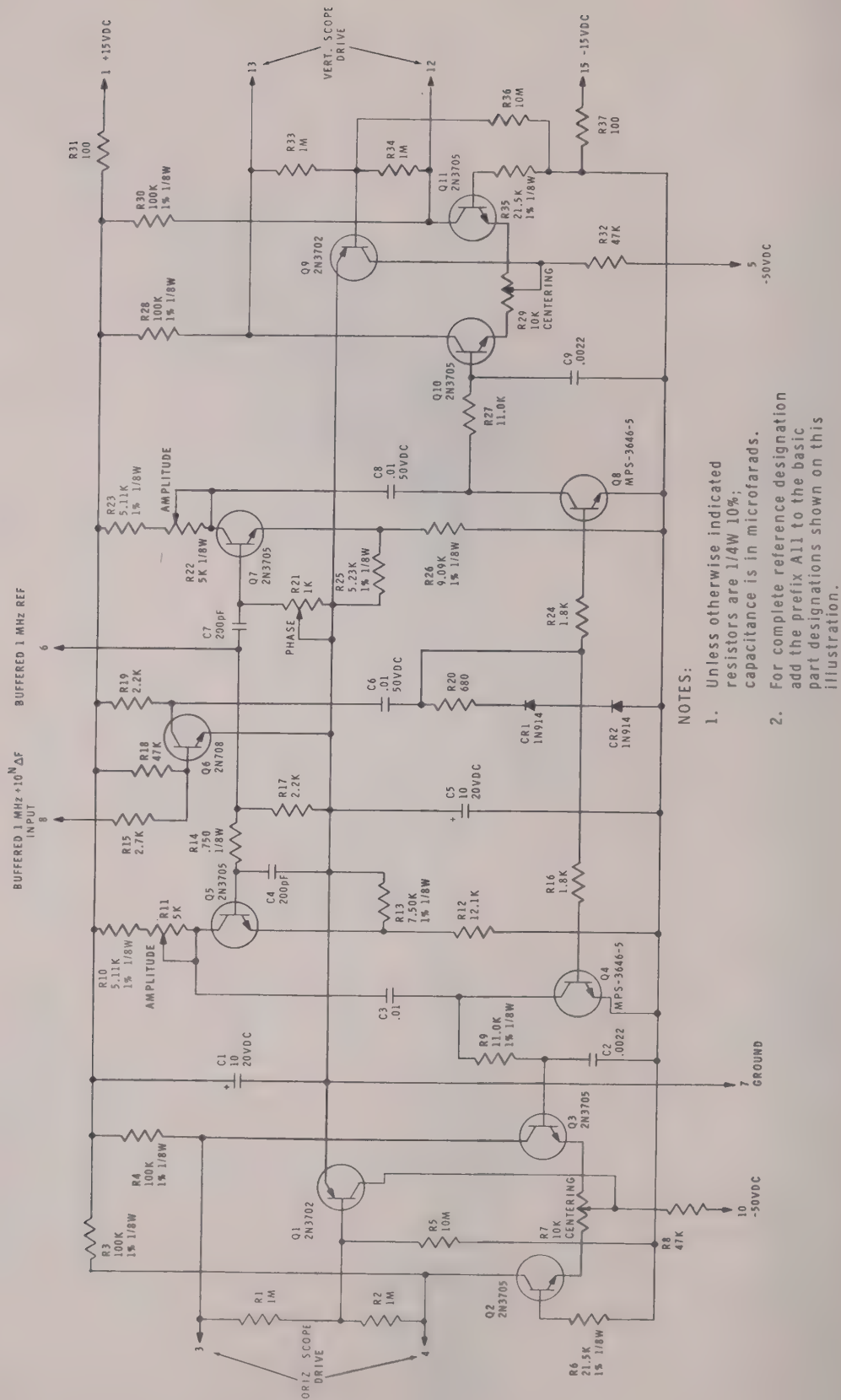


Figure 7-9. Schematic Diagram, Scope Driver (Assembly A11)

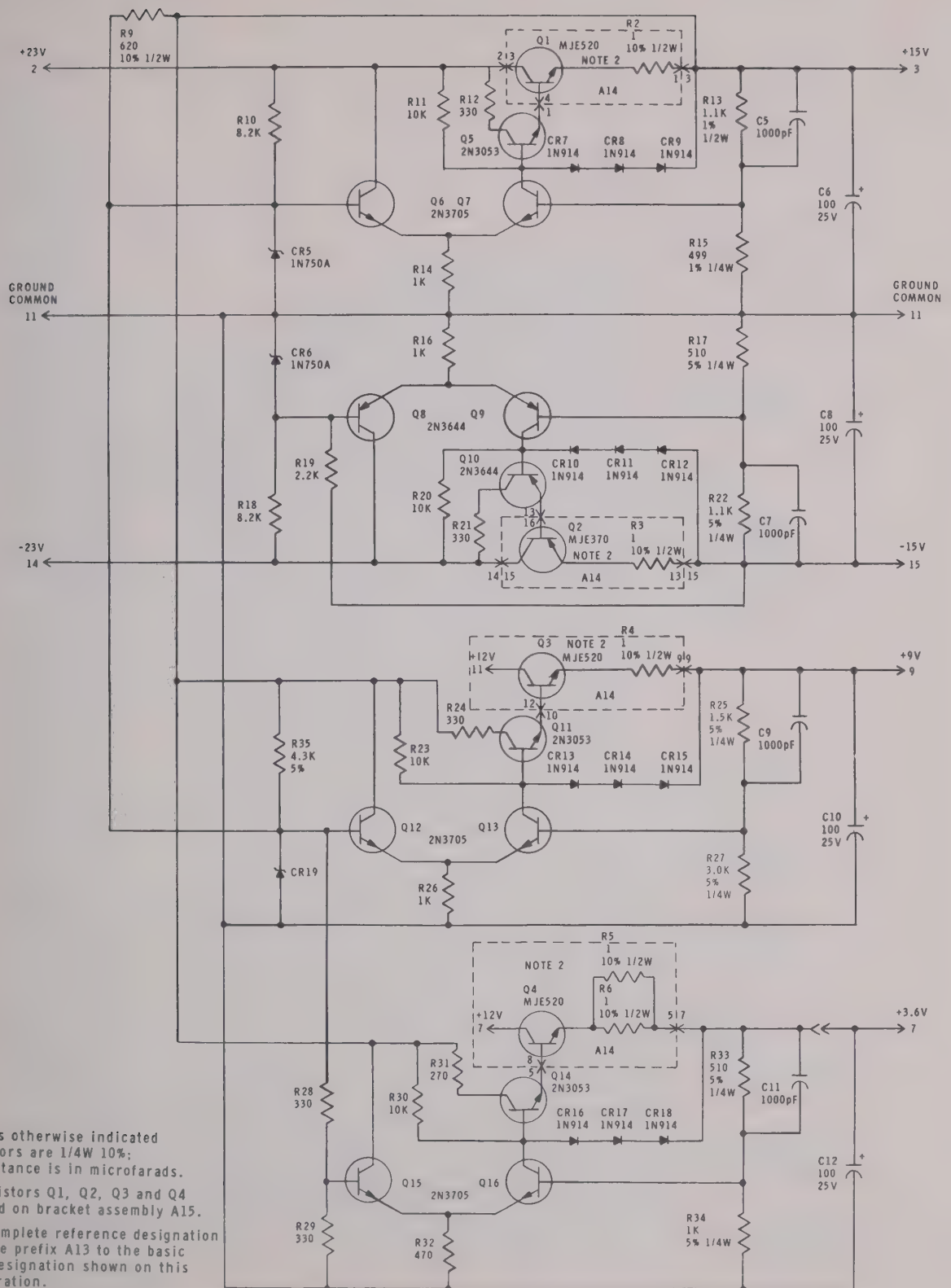
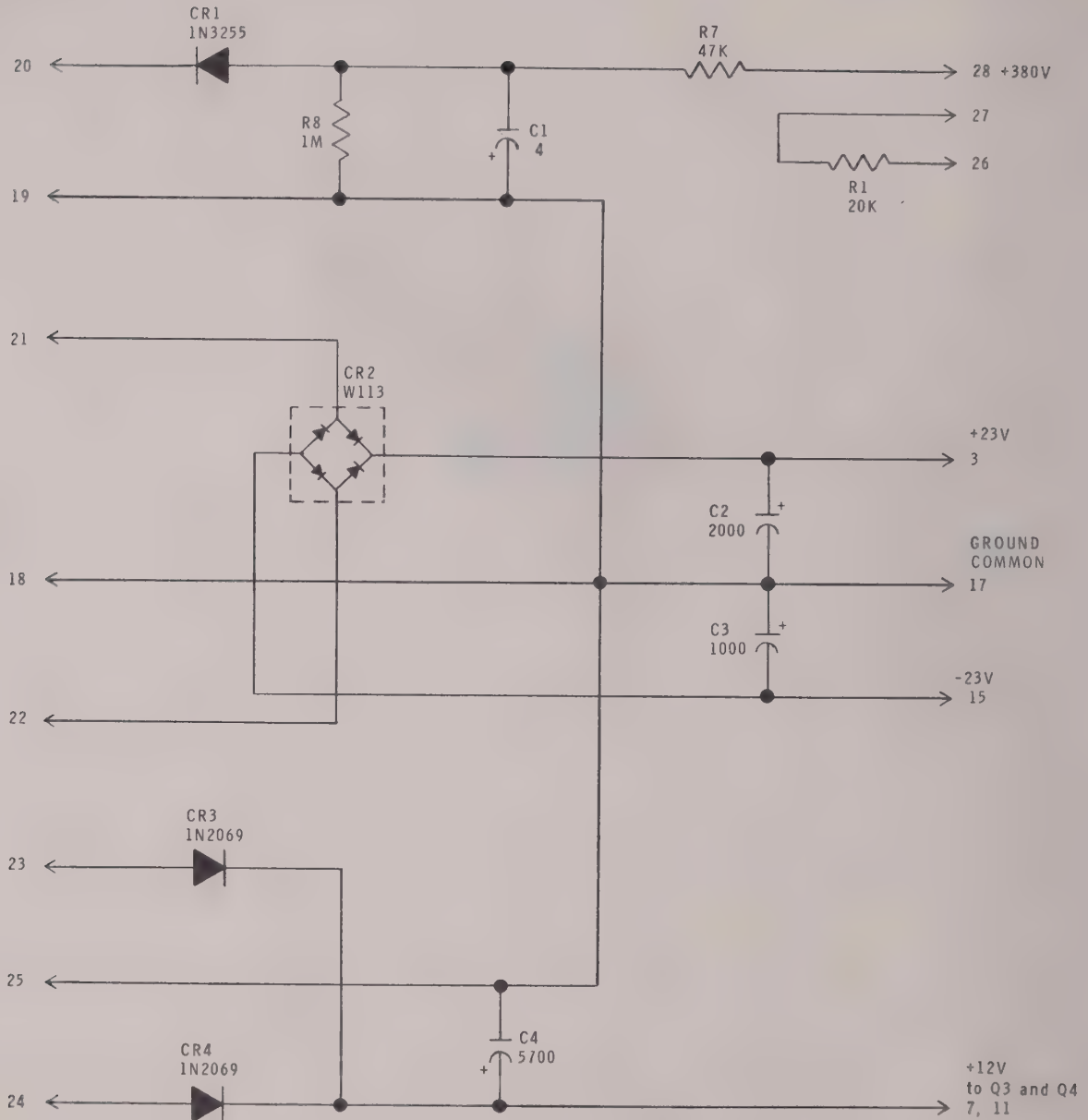


Figure 7-10. Schematic Diagram, Power Supply Regulator (Assembly A13)



- NOTES:
1. All resistors are 1/2W 10%; capacitance is in microfarads.
 2. R2, R3, R4, R5, and R6 are shown on power supply regulator schematic.
 3. For complete reference designation add the prefix A14 to the basic part designations shown on this illustration.

Figure 7-11. Schematic Diagram, Power Supply Rectifier (Assembly A14)

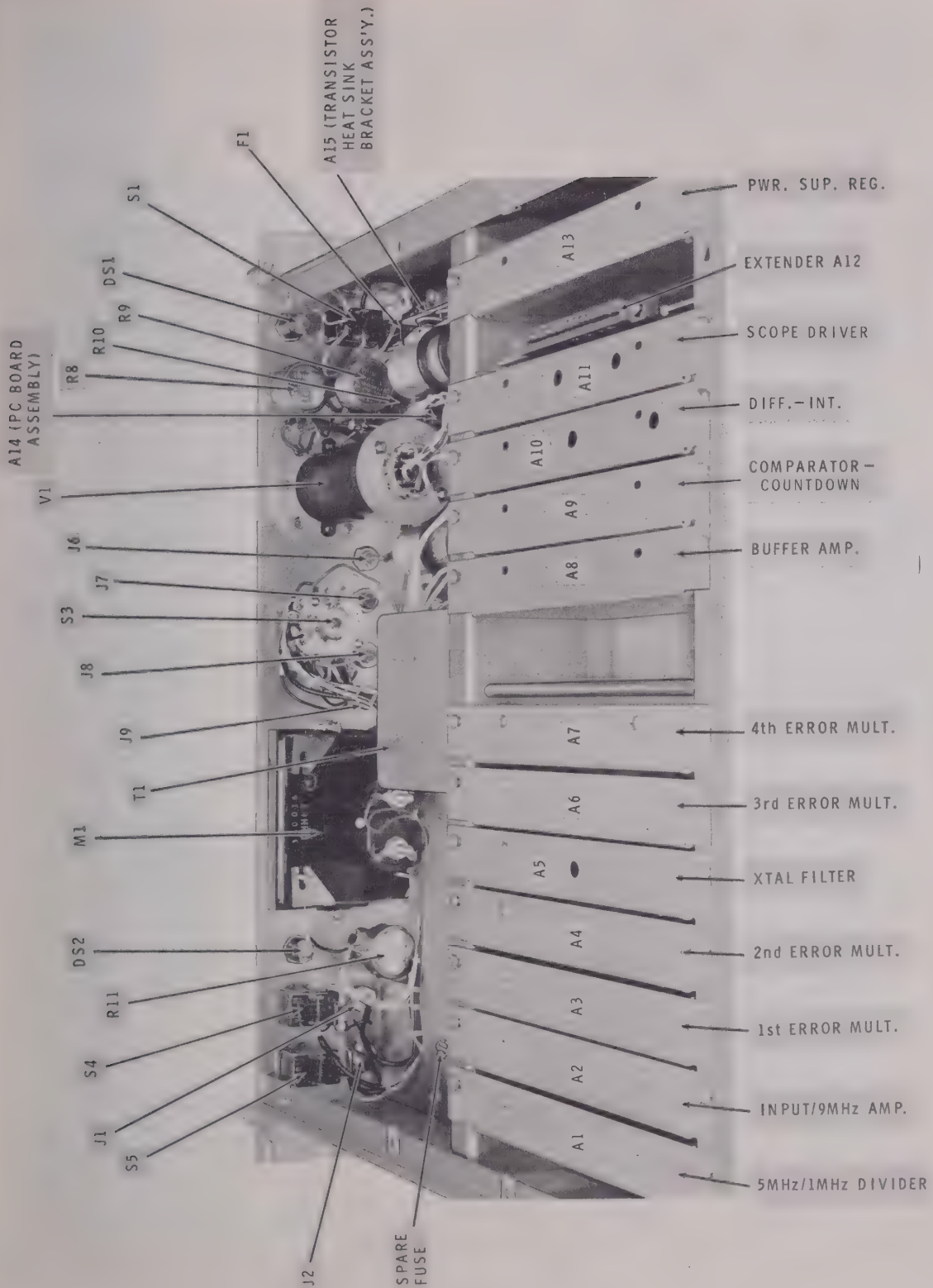


Figure 7-12. Main Chassis, Top View, Parts Location

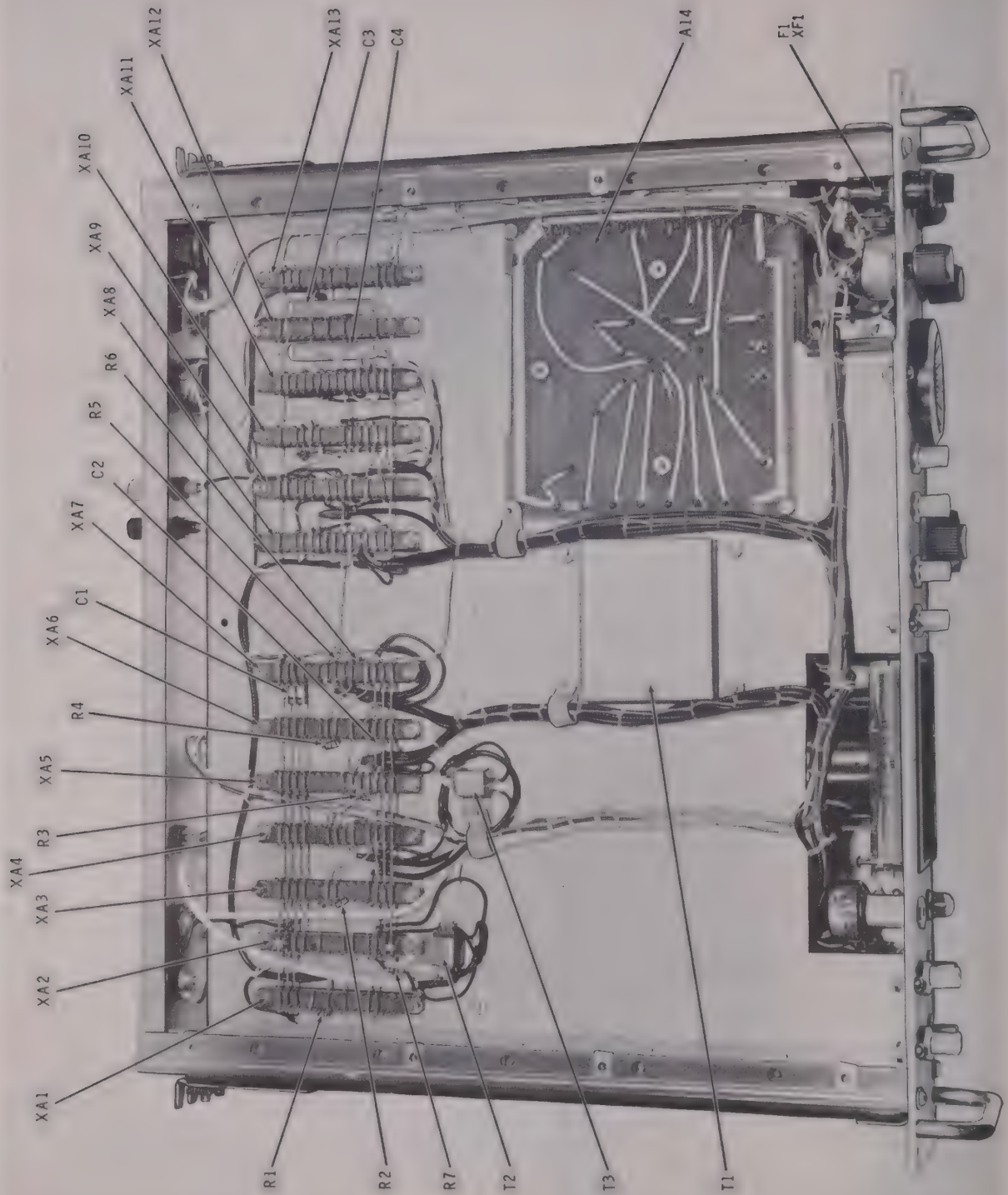


Figure 7-13. Main Chassis, Bottom View, Parts Location

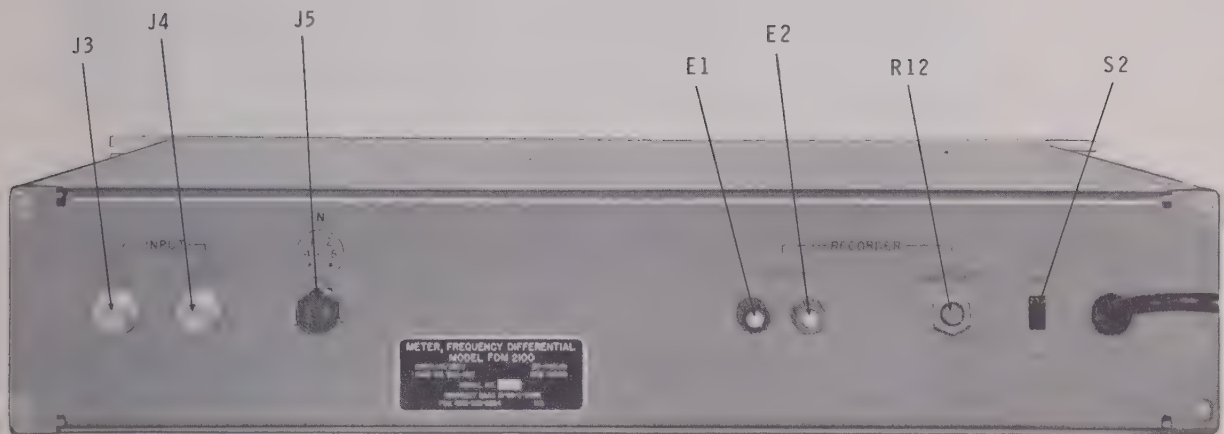


Figure 7-14. Main Chassis, Rear View, Parts Location

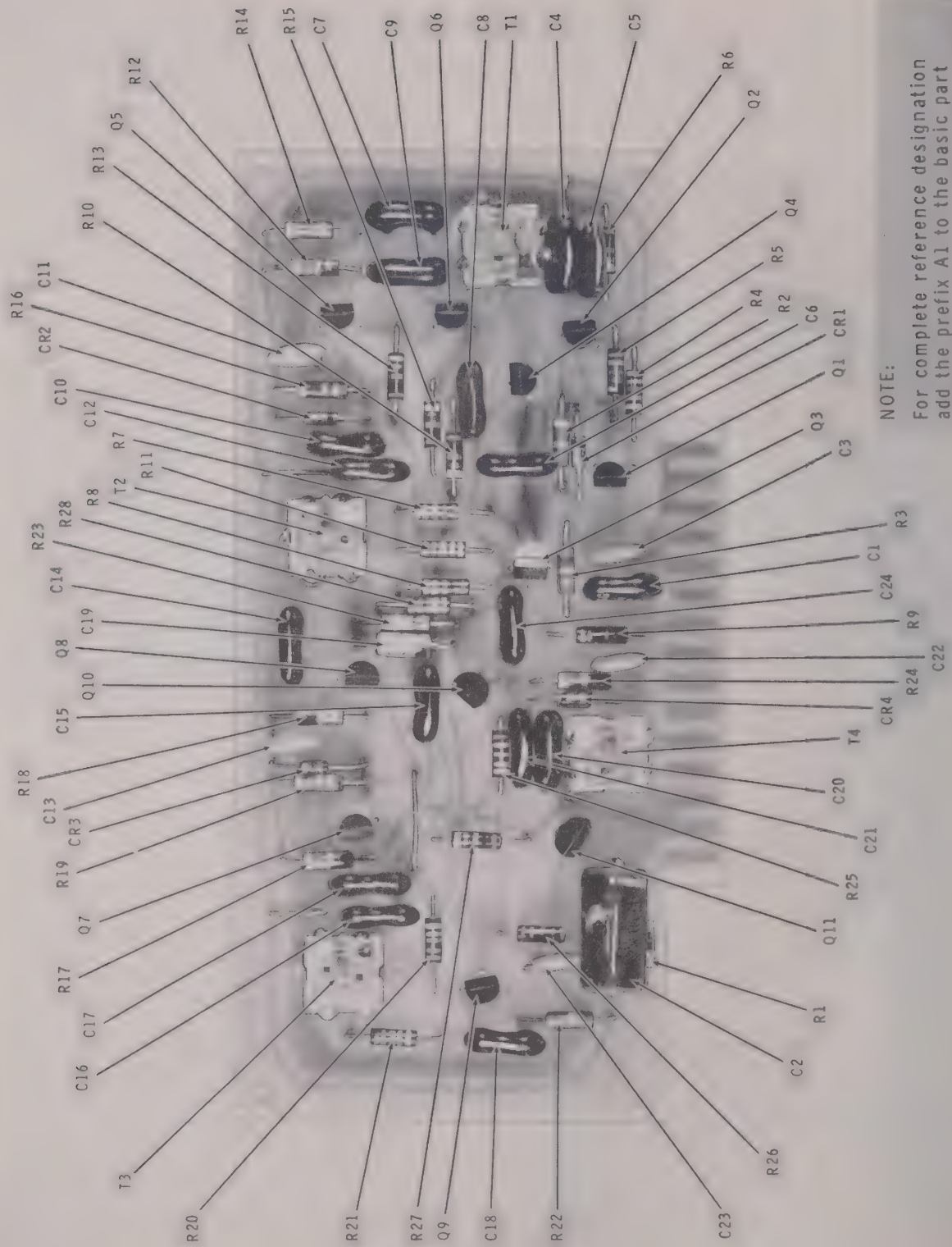
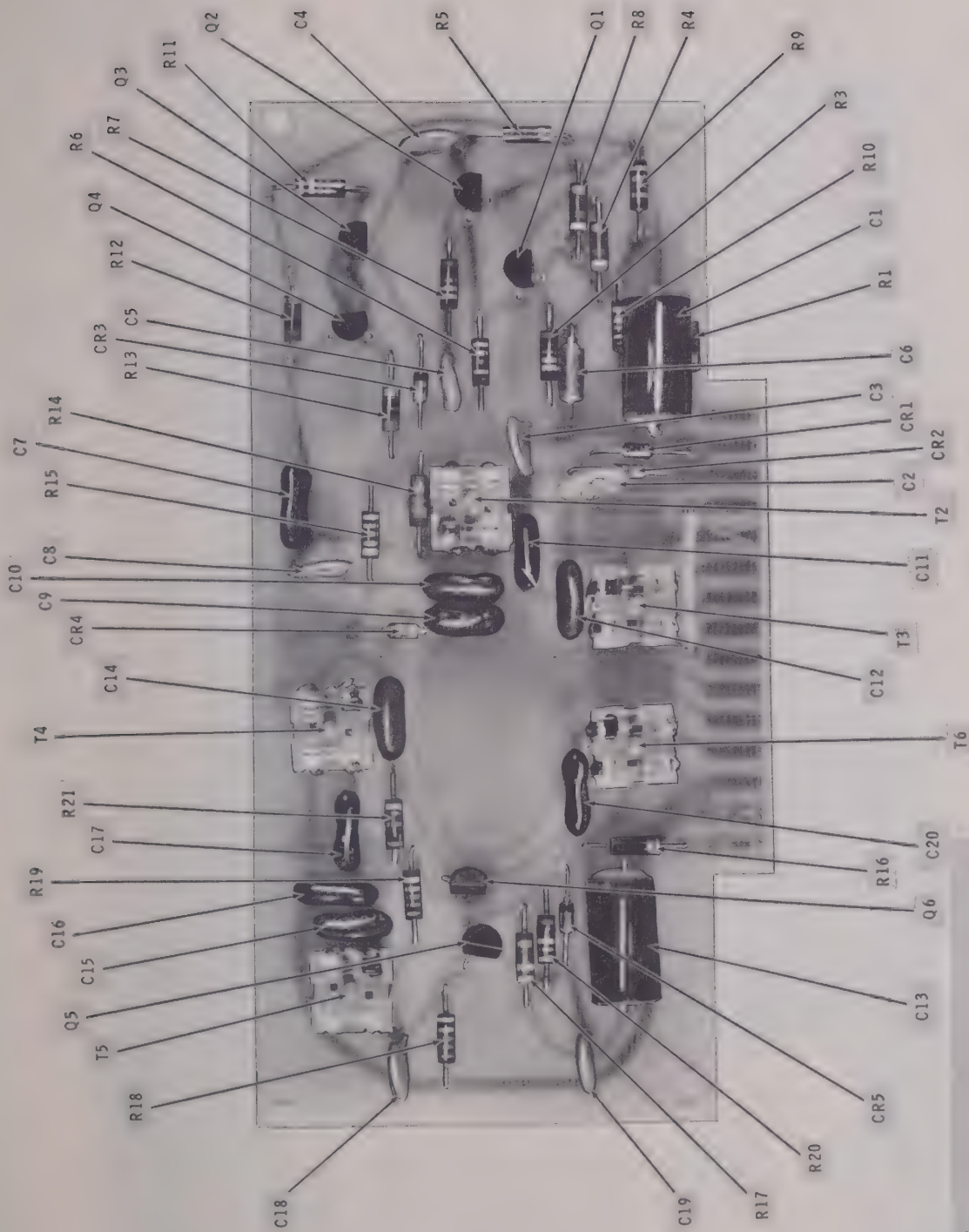


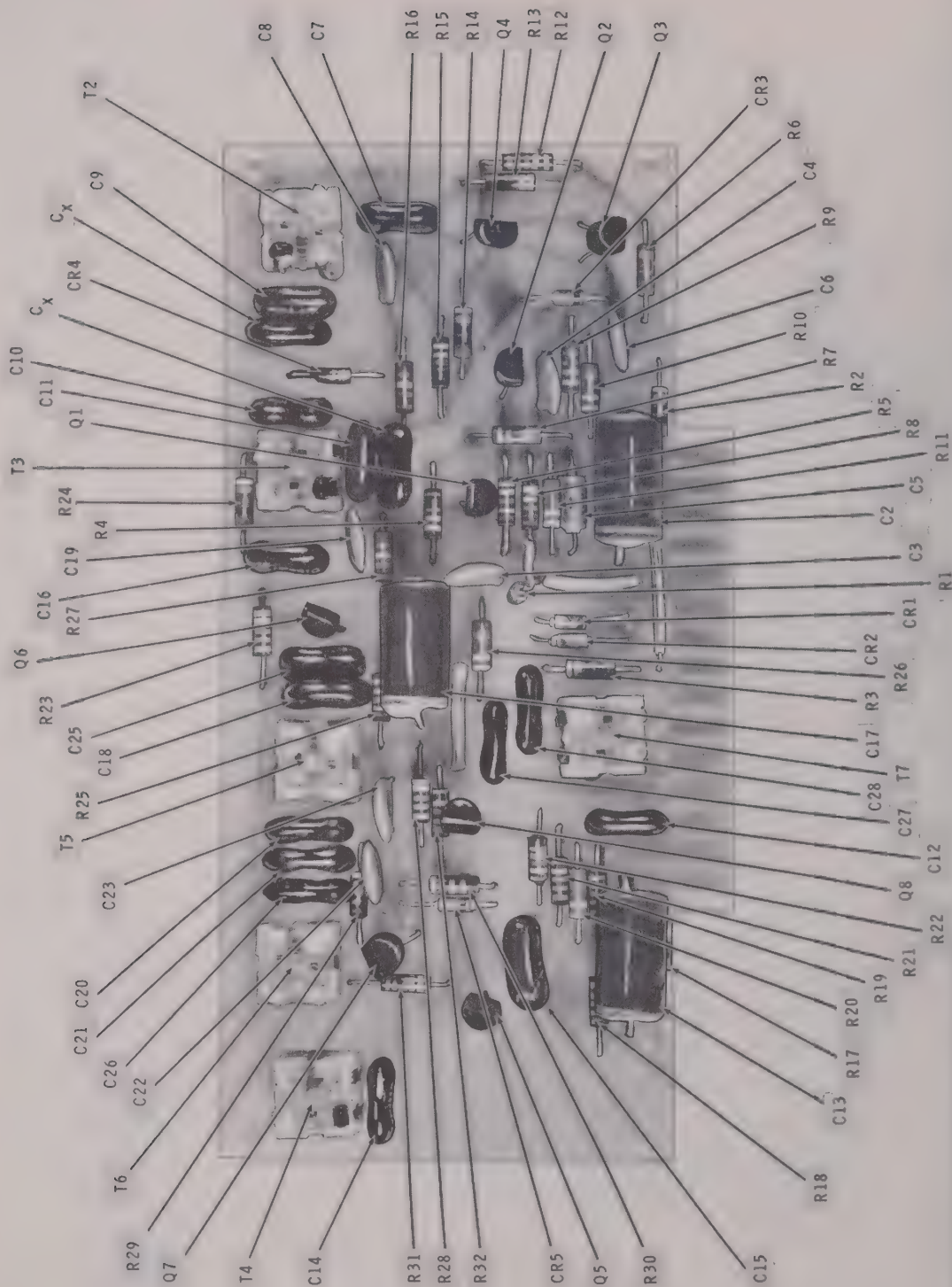
Figure 7-15. 5 MHz/1 MHz Divider, Printed Circuit Board, Parts Location (Assembly A1)



NOTE:

For complete reference designation add the prefix A2 to the basic part designations shown on this illustration.

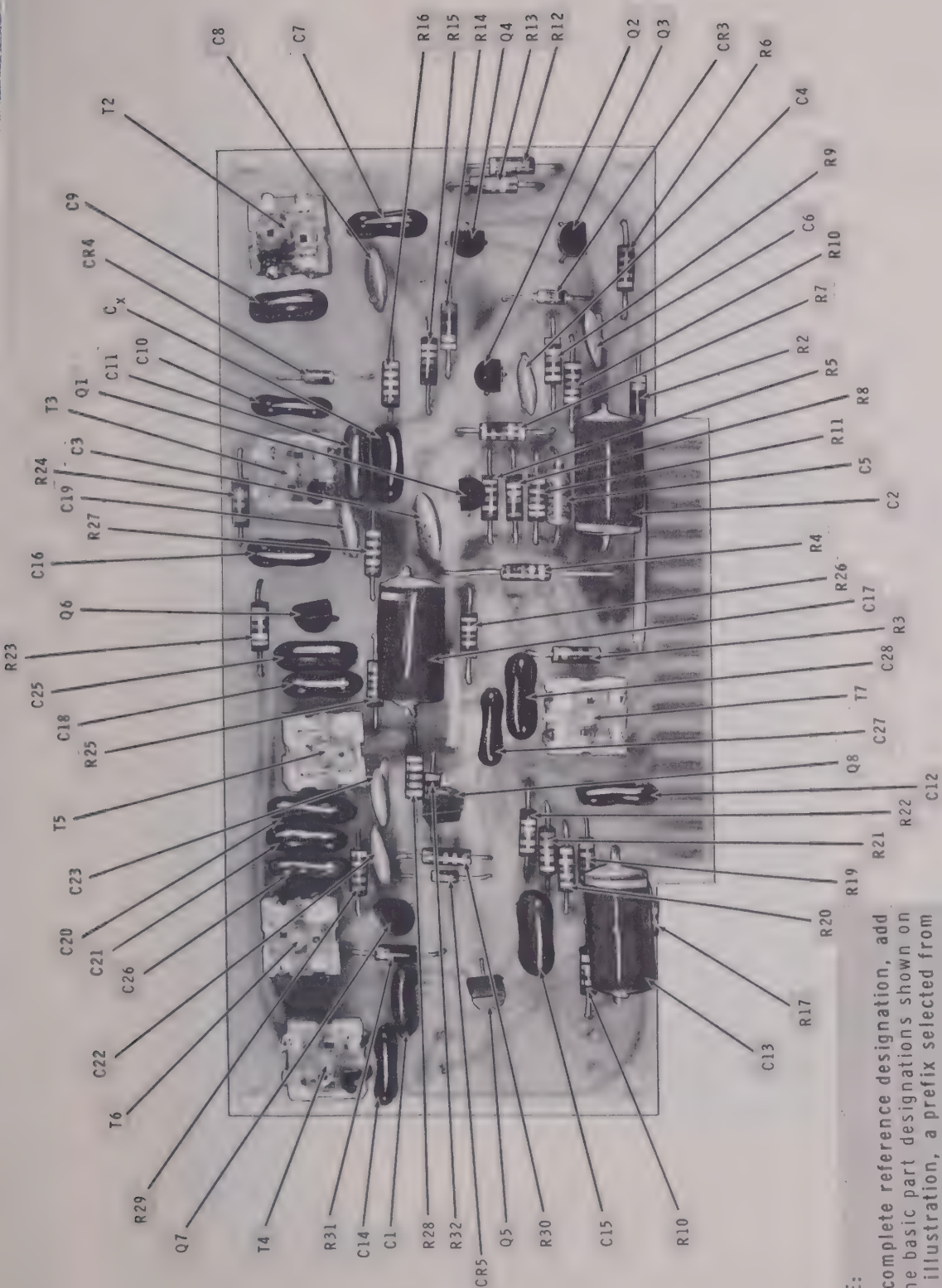
Figure 7-16. Input/9 MHz Amplifier, Printed Circuit Board, Parts Location (Assembly A2)



NOTE:

For complete reference designation add the prefix A3 to the basic part designations shown on this illustration.

Figure 7-17. First Error Multiplier, Printed Circuit Board, Parts Location (Assembly A3)

**NOTE:**

For complete reference designation, add to the basic part designations shown on this illustration, a prefix selected from the chart below:

- A4 - 2nd error multiplier
- A6 - 3rd error multiplier
- A7 - 4th error multiplier

Figure 7-18. Second, Third and Fourth Multipliers, Printed Circuit Board, Parts Location (Assemblies A4, A6 and A7)

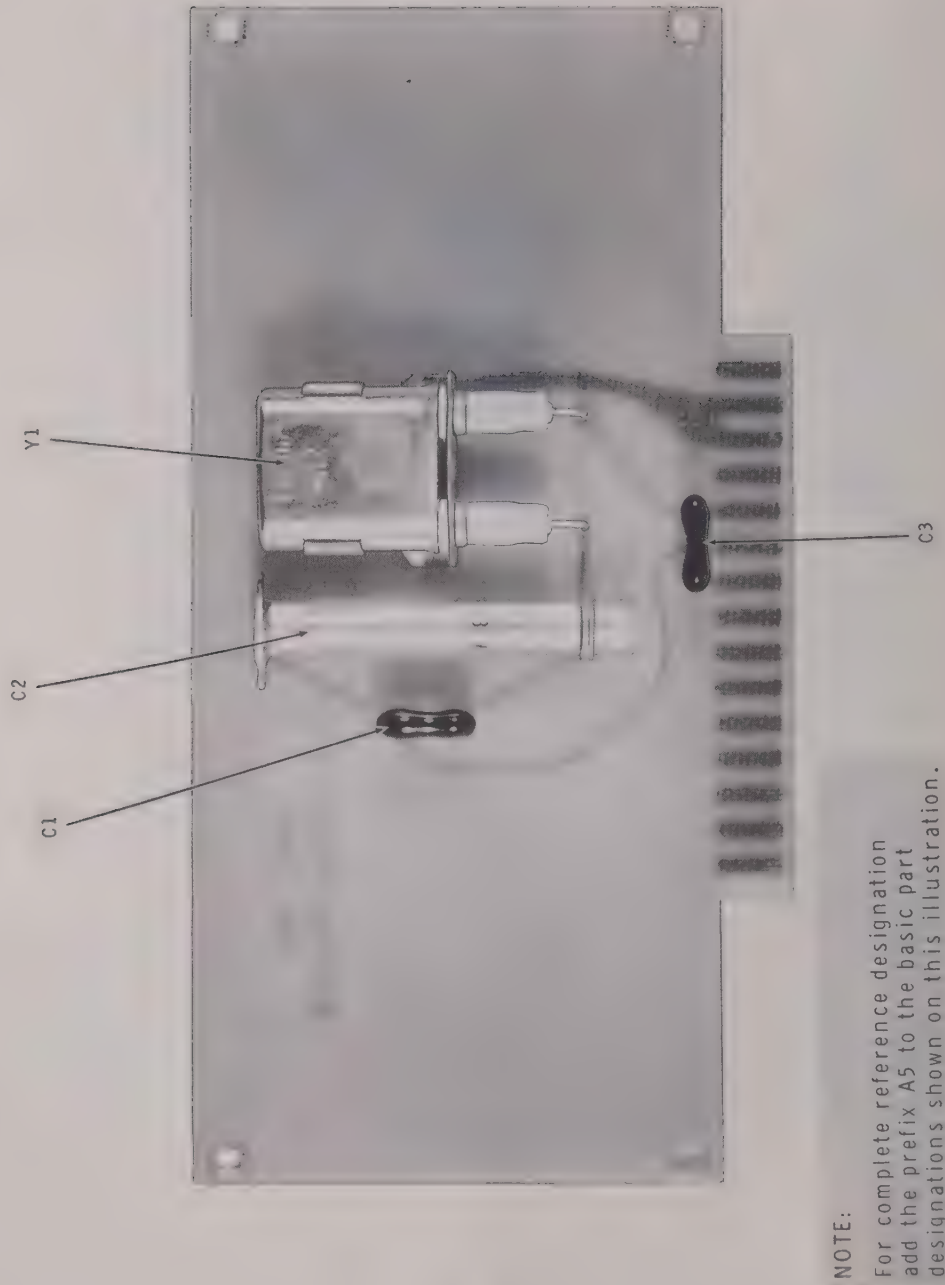
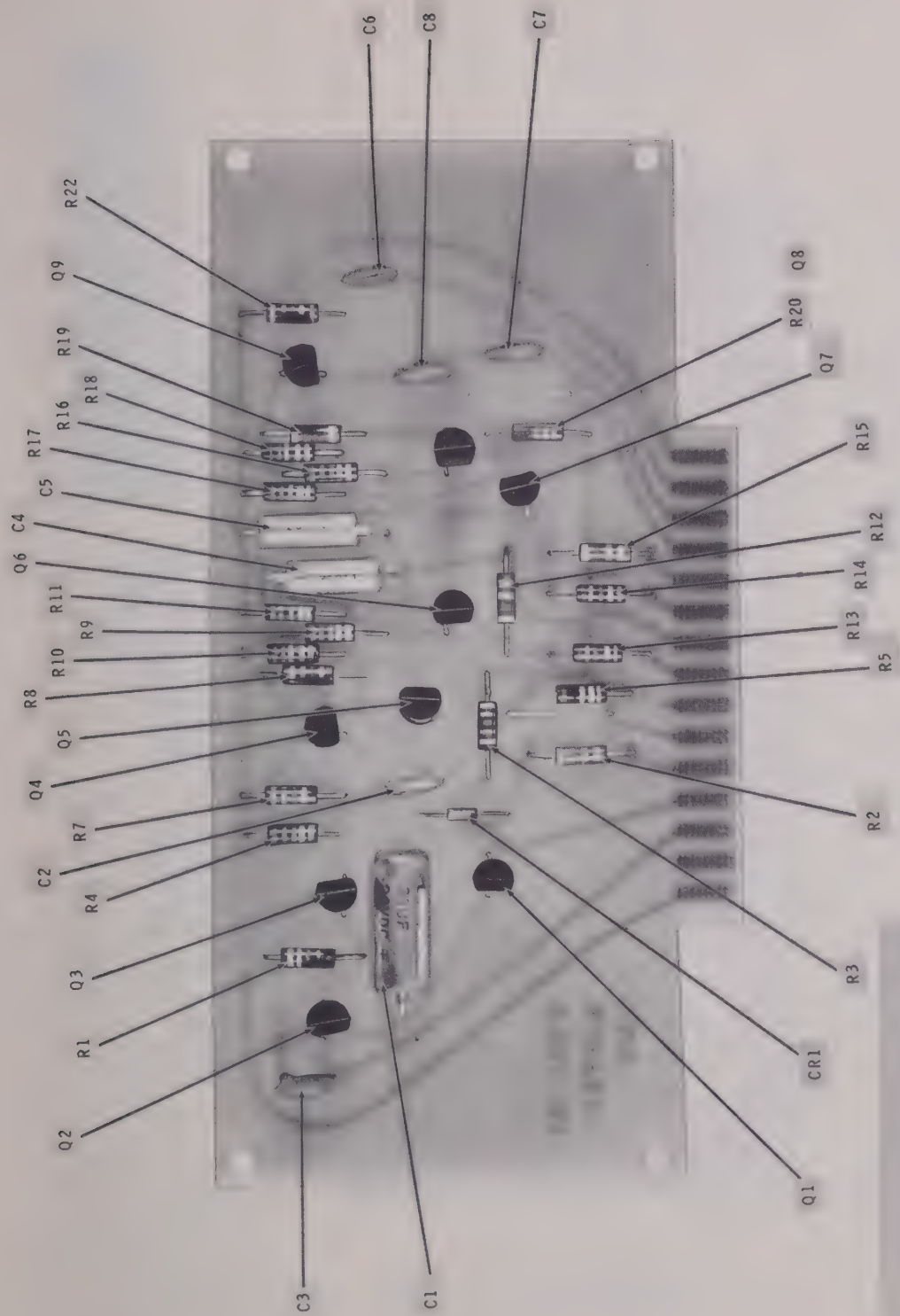


Figure 7-19. Crystal Filter, Printed Circuit Board, Parts Location (Assembly A5)



NOTE:

For complete reference designation add the prefix A8 to the basic part designations shown on this illustration.

Figure 7-20. Buffer Amplifier, Printed Circuit Board, Parts Location (Assembly A8)

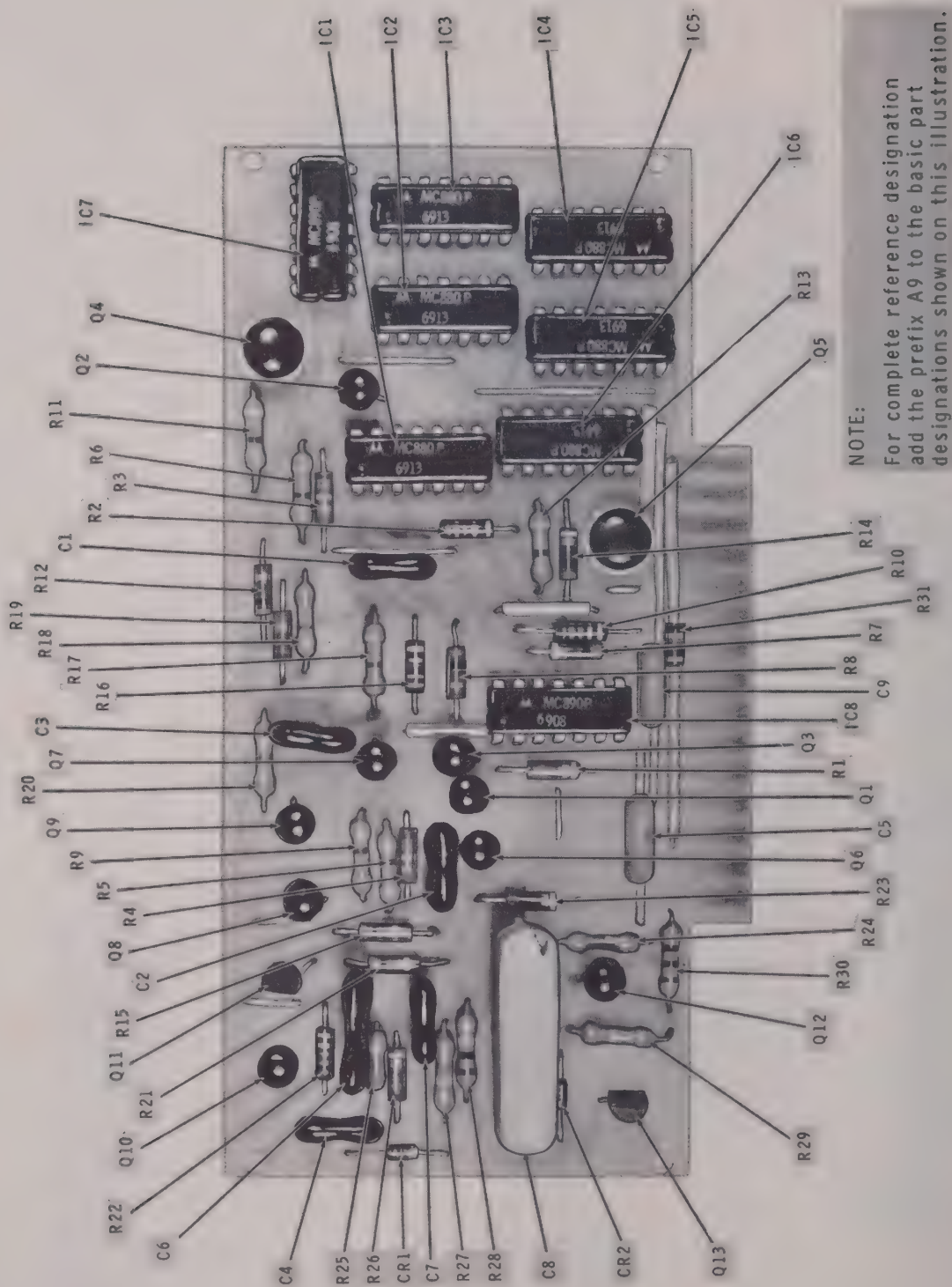
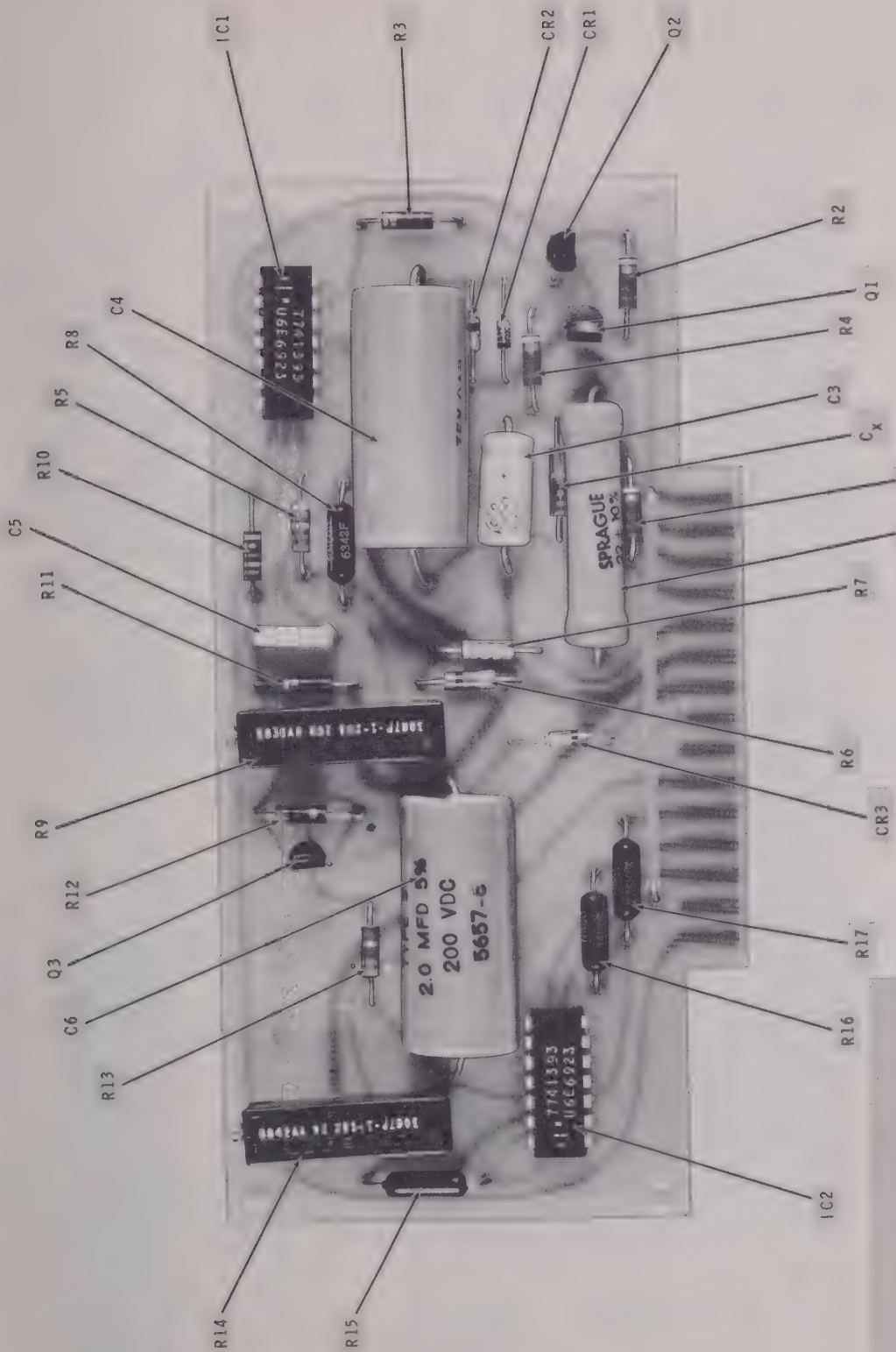


Figure 7-21. Comparator-Countdown, Printed Circuit Board, Parts Location (Assembly A9)



NOTE:

For complete reference designation add the prefix A10 to the basic part designations shown on this illustration.

Figure 7-22. Integrator-Differentiator, Printed Circuit Board, Parts Location (Assembly A10)

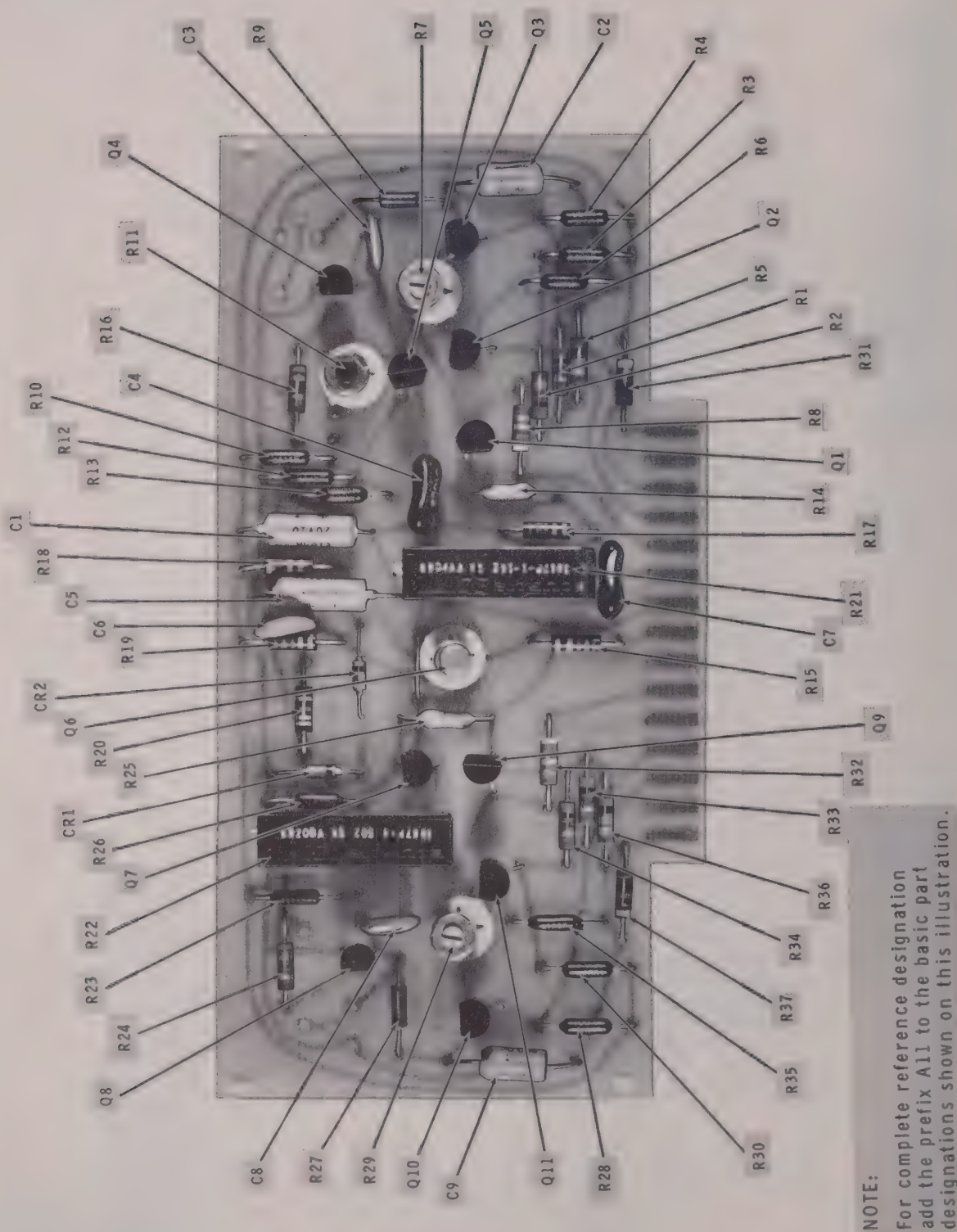


Figure 7-23. Scope Driver, Printed Circuit Board, Parts Location (Assembly A11)

NOTE:
For complete reference designation
add the prefix A13 to the basic part
designations shown on this illustration.

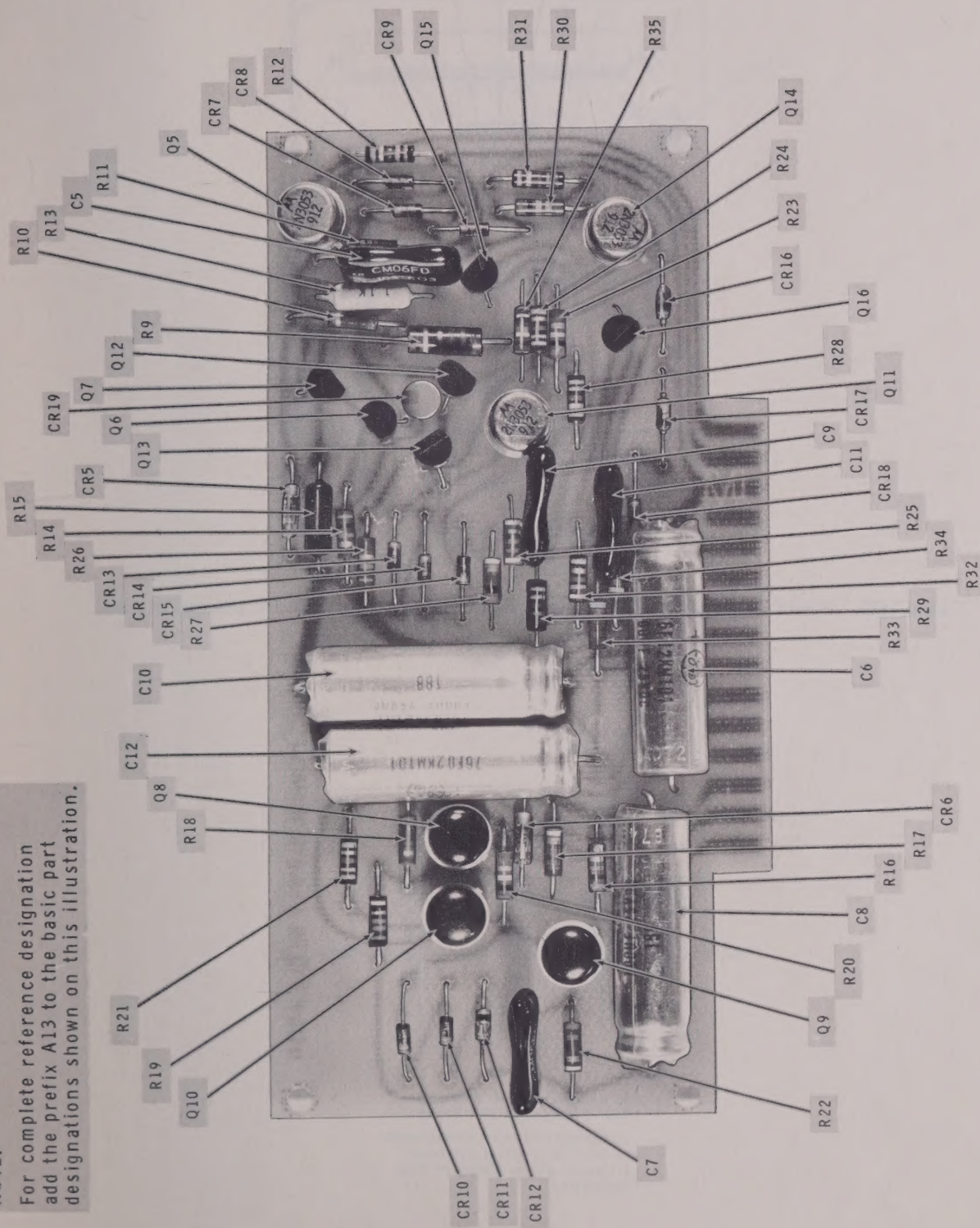
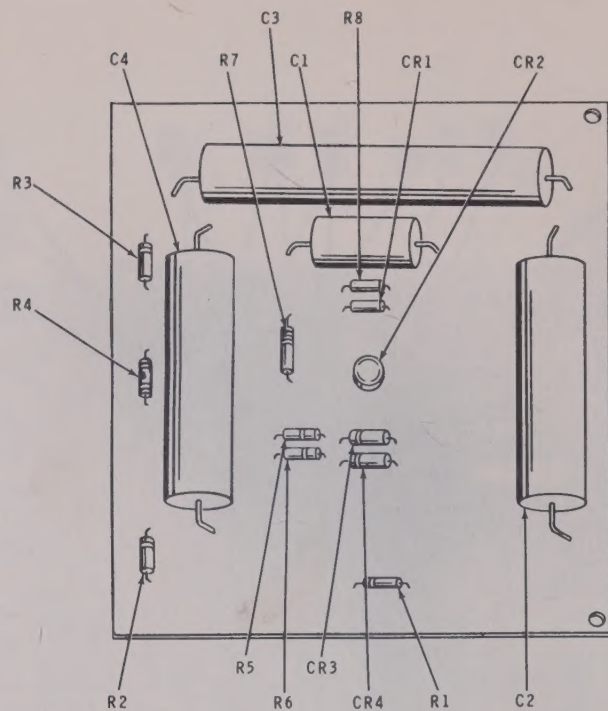


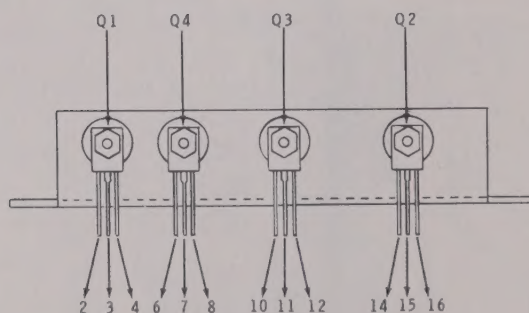
Figure 7-24. Power Supply Regulator, Printed Circuit Board, Parts Location (Assembly A13)



NOTE:

For complete reference designation add the prefix A14 to the basic part designations shown on this illustration.

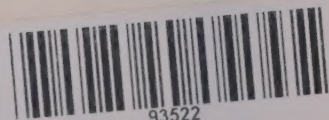
Figure 7-25. Power Supply Rectifier, Printed Circuit Board, Parts Location (Assembly A14)



NOTES:

1. Q1, Q2, Q3, and Q4 shown on power supply regulator schematic.
2. For complete reference designation add the prefix A15 to the basic part designations shown on this illustration.

Figure 7-26. Power Supply Transistor and Heat Sink Bracket, Parts Location (Assembly A15)



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